PB-217 842

INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD). INFORMATION BULLETIN. NUMBERS 1-12 NOVEMBER 1956 TO SEPTEMBER 1961

John S. Wiley

Bureau of Solid Waste Management
Rockville, Maryland

1969

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Groupe international d'étude pour les recherches sur les ordures ménagères

INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)

INFORMATION BULLETIN NUMBERS 1–12

November 1956 to September 1961

Edited by John S. Wiley, Sanitary Engineer Director

Bulletins 1 through 12, translated by Warren L. Armstrong,
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Bureau of Solid Waste Management
ROCKVILLE, MARYLAND
1969

INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)

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INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)

Information Bulletin No. 1

November 1956

X

1. Organization and first session of the International Research Group on Refuse Disposal (IRGR)

The participants in the International Symposium on Present Problems of the Removal, Treatment and Utilization of Domestic Wastes, held at the Federal Polytechnical Institute (School) in Zurich in July 1955, were able to affirm that collaboration on an international level, of the interested circles, would be desirable in order to solve the complex problems of the utilization of domestic wastes, problems which are posed in numerous countries. It was also decided that the organizations existing on a national scale should form an international study group, with the headquarters at Zurich, under the presidency of Professor O. Jaag.

With a view to discussing the prospectives of the newly founded Study Group and the most urgent studies to be undertaken by it, a certain number of interested persons were assembled at a meeting held at Scheveningen June 28-29, 1956, presided over by Professor Jaag, in which the following men participated:

Engineer A. W. v(an) d(er) E Plassche, Director-General, Ministry of Agriculture of the Netherlands, The Hague.
W.A.G. Weststrate, Director, Stichting "Compost", Amsterdam.
Dr. F. C. Gerretsen, Landbouwproefstation en Bodemkundig Institut TNO, Groningen. (Federal Agricultural Experiment Station Soil Culture Institute TNO)
P. de Graff, Director, International Association of Public Cleansing, (INTAPUC) The Hague.
C. Kachulle, Diplomate Engineer, German Working Circle for Research on Water and Sewage, Neuss-am-Rhine.
Dr. H. Straub, Business Director of the Commercial Union for Community Sewage Management (AkA) Baden-Baden.
Dr. U. Springer, Subdirector, Federal Institute for Plant Culture and Plant Protection, Munich.
Dr. O. Jaag, Director, Federal Institute for the Management, Purification and Protection of Waters, President of the Meeting at Scheveningen, from Zurich.
Dr. R. Braun, Federal Institute for the Management, Purification, and Protection of Waters, Reporter (recorder of the Minutes) of the Meeting at Scheveningen, from Zurich.

During the course of the session, the participants made obvious the need for coordinating the projects conducted by the specialists of the various European laboratories and institutes and for introducing methods of analyses and of standardized tests, as for example already exist for waters and waste waters (standard methods) in considerable numbers. By such a coordination of projects and by standardization of tests and analyses, we can avoid not only the useless duplication of studies, but we will also thus probably solve the riddle of contradictory results of analogous studies. It being granted that meetings and conferences organized at irregular intervals constitute an insufficient source of information, the distribution of a periodic information bulletin, published in French, German, and English, would be highly desirable.

After thorough discussion it was decided to endow the IRGR of which the seat would be in Zurich (EAWAG) and which will be directed by M. Braun. The duties of this secretariat would be:

1. To publish a periodic information bulletin for the benefit of specialists in the subject and for interested persons in the various nations (in English, German and French). To collect the publications and reports edited by the specialists, inspect them according to precise and orderly criteria, and distribute them in a bulletin of information. In this way, the various laboratories will have available a valuable source of information, which will inform them rapidly and continuously. Among others, the Swiss Review of Hydrology (die Schweizerische Zeitschrift für Hydrologie) (la Revue suisse de Hydrologie) Birkhäuser Publishers, Basel, accepts papers of a scientific nature. Manuscripts containing a maximum of 16 printed pages should be addressed to the editor (Prof. Dr. C. Jaag), who will decide as to their eventual publication in the Review.

2. To function as an information bureau; i.e., to reply to questions.

3. To send reprints to those who ask for them, and the same for any other publications made available to the Secretary by the individual authors.

4. To draw up general reports on the progress made in the scientific study of domestic wastes on the basis of information furnished by the individual experts.

Ways and means of financing this Secretary's office were thoroughly discussed. For the moment, it will not be collected by individual contributions. The participants in the meeting at Scheveningen decided upon a common agreement with the countries interested in the IRGR activities to send a yearly contribution. Germany, Holland, and Switzerland have already made a payment.

The IRGR cannot be definitely constituted until after suitable statutes have been drawn up and enacted. The Secretary is going to draw up a list of statutes which it will submit at the next meeting. The following dispositions are to be provided:

The International Research Group on Refuse Disposal is to be composed of a Bureau and a Scientific Commission. The Bureau (Board) is to be composed as follows:

Professor Doctor O. Jaag, President
Director W.A.G. Weststrate
Diplomate Engineer C. Kachulle
A representative of INTAPUC
Dr. R. Braun, Secretary

(INTAPUC - International Association of Public Cleansing)

The composition of the Scientific Commission cannot be definitely fixed as yet. It will consist of two representative experts from each of the different European countries, who have proof of active participation in work and research activities on a national scale. These experts should be ready to collaborate with the IRGR and to establish a liaison between it and the interests of the countries they represent. This requires the activities of trustworthy men and signified to IRGR, among other things, persons capable of being interested in the reports and bulletins of the IRGR. To simplify the work of distribution, the secretariat of the IRGR may send a certain number of copies of the bulletin to each of the national representatives, who, in their turn, can send them to definitive destinations. During the first year, provision was made to send these documents free to the various countries. The question as to the eventual price of the bulletin or number can be worked out later. The main thing is that the IRGR and its secretariat begin working immediately. The reports presented at the Scheveningen meeting are published in Information Bulletin No. 1.

At the end of this first meeting of the newly founded study group, the president was able to affirm with satisfaction that all the participants had manifested their good will towards an intensive collaboration. To the general regret of all the participants the representatives of France and Great Britain were unable to take part, being unable to come to Scheveningen; nevertheless they expressed a lively interest in the further activity of the international study group and also hoped they could participate in subsequent meetings.

2. The necessity for standard methods of analysis and evaluation of refuse compost.

(Brief report, presented by Dr. O. Jaag at the first meeting of IRGR)

For years, the Institutes of Europe and America have been working with the manifold problems posed by the removal, treatment, and use of domestic wastes. However, a whole series of fundamental problems still await a definitive and satisfactory solution. We propose to choose from among the numerous questions still hanging fire those for which the solution is most urgently needed.

As for we Swiss professional men who are concerned about the problems of the disposal of domestic wastes and who should advise our communities in this field, it seems to us that the most urgent need is the establishment of general criteria which will permit the evaluation accurately of a compost of domestic wastes. These should be sufficiently distinctive to be capable of application to compost for different purposes, whether agricultural, horticultural or sylvicultural. They should give information on the structure, fertilizing value, trace elements, etc. thus all the properties that make composts from domestic wastes valuable. They should also be applicable in the different countries. A study group should be formed within our organization to work out these problems. Only when we know the favorable attributes and also the disadvantages of a given compost can we then proceed with appropriate techniques to manufacture compost in such a way as to obtain the qualities desired.

At the present time opinions as to the value of composts of domestic wastes are widely divergent. The agronomical experts, at least in Switzerland, only recognize the value of a compost when it is in such a condition that it furnishes nutritive substances. All the other characteristics of compost appear to them to be of a minor or negligible value. We do not believe that the value of a compost is exclusively a function of its content in nutritive substances. The organic substances, the porosity of its structure, the ability to retain water, the storage and slow release of organically-combined nutritive substances, and other factors can without doubt play a significant role in the practical use of a compost, in special cases in which the aim is to loosen up the soil or to enrich it in humus, or to enhance the ability of the soil to retain water. These special purposes should be taken into consideration in the evaluation of a compost. Besides, the degree of fermentation, the porosity, the content of glass, cinder, etc. play a significant role.

Many compost enthusiasts praise compost because of the "vitalizing forces" inherent in it. Just what they mean by that they are generally unable to say. But despite this they value the compost according, so they say, to strictly scientific methods. Because of this, however, their judgment is often opposite to that resulting, e.g., from trials made in agriculture.

Our problem is now to attempt to clear up these questions. That is why it should be begun by formulating these questions that are posed in such a way that the research pursued in the various nations might be oriented according to the results enabling them to be applied with confidence generally to the cases in all the countries.

The establishment of criteria and the introduction of test methods for the evaluation of the quality of compost appears to me therefore to be the first objective of our international study group.

3. Research work in the treatment and utilization of urban domestic wastes.

(Short report presented by Dr. F. C. Gerretsen at the first meeting of IRGR)

The problems for which the investigation is of significance for the further development of the composting of urban domestic wastes (refuse) may be divided into four categories:

1. How should refuse be prepared in order to obtain good compost?

2. In what way and for how long a time beforehand should the compost be made, in order to obtain a product which will be best suited to agricultural uses?

3. How should compost be used in agriculture and horticulture in order to obtain the best possible results?

4. From whence do the different effects of compost originate?

It is not the purpose of this report to treat all these problems fundamentally, especially since my knowledge of these problems in theory and in practice is confined chiefly to their bacteriological aspects. However, since compost originates largely through microbiological processes, bacterial physiology can furnish us with essential information.

I wish to expound on some of the main objectives of research on the basis of my own experiences and on some examples of practical application in the Netherlands. It is possible that the problems are presented in a slightly different light than in other countries, yet are basically the same.

One question which comes up again and again concerning the procedure of making compost from refuse is whether the waste should be ground up before or after composting.

I presume that the compost should be free from fragments of glass and debris, and will confine myself to the question as to effect of pulverizing on the process of composting.

Aeration is better in coarse, unsorted refuse than in finely ground material, and it is to be expected that the raw wastes can be piled higher and in heaps of greater size than the finely divided matter. In our country the coarse waste is deposited in piles up to 6 meters high in the vast installations of Wijster and Nuenen, while in the installations at Schiedam, Delft, etc. the piles of ground-up waste are less than 2 meters high and occupy a lesser area. These figures have been established by long practice but it would definitely be of interest to study this question with greater exactitude.

This is one of the questions I am investigating at present. Samples of gas were taken with a probe from different positions in the compost heaps. These gas samples were analyzed for their content of carbon dioxide, oxygen, and other gases. The probe consisted of a copper tube enclosing a capillary tube. The conical point of the probe is so constructed that in taking the sample no particles of compost penetrate into the tube.

In an 8-month-old pile of refuse compost which had attained maturity in Wijster, I found 8.8% of carbon dioxide and an excess of oxygen at a depth of one meter. In the deepest levels of the 6-meter-high heap the gas consisted of 32% carbon dioxide, 1.4% oxygen, 2% hydrogen, and 2.6% methane. In the lower portion of this heap, the conditions were thus completely anaerobic.

Another sign indicating insufficient aeration is a black coloration of the compost, which is due to the formation of black ferrous sulfide. Although it is inevitable that processes of reduction occur to a limited extent at the bottom of the piles, it is undesirable when this phenomenon occurs to a greater degree. In case of anaerobic decomposition, products may easily be formed that are injurious to plant life. Moreover, in such cases the temperature does not rise, which not only prolongs the process of decomposition, but renders impossible the greatly-desired destruction of pathogenic bacteria and weeds.

It is thus indispensable to control systematically the temperature in the piles of domestic wastes, and it is the temperature which gives the most certain information concerning the progress of the process of decomposition.

A question of great importance is that concerning the duration of composting. The answer is not easy, because that duration depends upon the purpose for which the compost is to be used. Compost that still contains much organic material and much carbon but little nitrogen, fixes that nitrogen in the soil and may seriously damage the plants. I say may because this is particularly dependent upon the time at which the compost is used. The use of an insufficiently decomposed compost immediately before seeding is injurious, because the plants suffer from a lack of nitrogen as a result.

The investigations of my colleague Engineer Kortleven, have shown that the use of incompletely decomposed compost in the fall gave better results than the use of decomposed compost in the spring. The reason is that the presence of considerable quantities of paper forces the bacteria of the soil to utilize the nitrogen of the soil for the decomposition of the cellulose and to fix that nitrogen in their bodies. In this way the nitrogen is preserved through the rains and snows during the wet period of the winter despite the work of erosion and leaching, and in the spring, after the decomposition of the bacteria, it is again available to the plants. In my opinion this finding,is of great significance, because the possibility is thereby raised of bringing ground-up domestic wastes immediately to the fields without any preliminary composting.

In our country, quite large amounts of this pulverized, unfermented compost are used for heating hot beds. However, it should be remembered that after the repeated use of 200 tons of compost containing about 2 to 3% calcium carbonate per hectare (2.47 acres), corresponding to about 4,000 Kg. of calcium carbonate, damage appears very quickly caused by too high a lime content.

I have already mentioned on the occasion of the Symposium in Zurich that we make the excess lime harmless by the addition of sulfur. The sulfur bacteria oxidize the sulfur and transform it into sulfuric acid, and calcium sulfate (gypsum) is formed. Such measures are only practicable, however, for the use of compost in horticulture, where an ever-greater deficiency in horse manure is being felt. It was believed that these measures would result in making the soluble salt content of the soil too high; it was shown, however, that the use of a like amount of horse manure incorporated still greater amounts of inorganic salts into the soil.

The question of the mixture of digested sludge with municipal refuse is of great importance in many countries. We have undertaken some planned experiments concerning this and have drawn from them the following conclusions: without any difficulty, 30% of digested sludge may be added to the dry refuse. Fermentation runs a normal course, and neither in the chemical analysis nor in the bacteriological tests could we detect any considerable differences. The nitrogen content rose from 0.41% to 0.49% which corresponds to an increase of only 0.08%.

In one such trial, 4 tons of fresh refuse was mixed with 1, 2, 4, and 8 tons of digested sludge, with a water content of 95%, and then composted. The composts thus obtained were compared by my colleague Kortleven with a compost from the same source, but to which was added only one ton of water. He made the comparisons at a pilot plant where 34 tons of compost were added per hectare of soil, for each trial.

It was shown that, in all experiments with composts of mixed refuse and sludge, an increase of about 5% resulted in the harvests.

Besides, the fresh wastes may be utilized as a filtering medium for the undried sludge. In this way at least 200% of sludge can be mixed in with the domestic wastes. It appears that the sludge is absorbed by the wastes after the manner of a colloid, while most of the water drains off at the base of the waste. It would be of value to repeat such experiments on a large scale, because they might make an important contribution to the solution of the problems of the sludges coming from sewage treatment plants.

At this time it should be mentioned that, unfortunately, in our country their is still a series of small communities which possess no sewage systems and which still get along with the insanitary cesspools as used long ago.

In Sneek, for example, this method has been combined with a modern system of grinding, and about 30% of the sludge is mixed with the finely ground domestic wastes. It is surprising that this mixture is almost odorless! In the laboratory it has been observed that this mixed compost is superior to the usual compost without fecal matter. The yield was considerably higher and the nitrogen content was about 10% higher than for common compost.

It is evident that the procedure requires a decomposition temperature of at least 55° to 60° C, not only to destroy the pathogenic microorganisms, but also to prevent the proliferation of ascarids (roundworms). The question is further to be tested by composting fecal matter with peat especially with frozen peat waste, which is almost worthless, since it cannot be converted into fuel. However, a product is obtained which is rich in valuable organic materials, which finds a willing acceptance in horticulture, and which can be sold at a higher price than ordinary compost.

In this connection the question is raised as to how far the composting industry should concern itself with the manufacture of more or less refined products. In general this would not be desirable. There are instances, however, when the composting enterprise is the appropriate site for the application of special measures; for example, many horticulturists have asked us whether we would be able to furnish a compost which, in its gradual release of nitrogen activity, would approximate that of horse manure.

It is perfectly possible to prepare such a compost, because the desired slow release of nitrogen occurs during the gradual decomposition of nitrogen compounds, which have been fixed in the bacterial bodies as proteins during the bacterial transformation of the compost. Laboratory experiments have shown that with the addition of about 0.5% nitrogen (in the form of calcium nitrate) to the fresh wastes, this soluble nitrogen has become completely insoluble in the course of five weeks, and is transformed into bacterial protein. From this point on a regular decomposition of the fixed nitrogen compounds begins, and after about 12 weeks we find all the nitrogen added in the beginning is again changed into a form assimilable by the plants. In the first experiments of this nature an error was made. After having added to the fresh waste the soluble nitrogen, normal composting was proceeded to the end, or about 3 months. But in the fermented compost, the protein compounds that were formed at the beginning had been decomposed long ago; we had therefore gone too far. The composting should therefore be stopped at the moment when the inorganic nitrogen has almost completely disappeared. Although these experiments have still not been concluded, it is to be expected that in this way a product will be obtained that will closely resemble horse manure. It is clear that the manufacture of such an improved type of compost should preferably be vested in the composting plants themselves.

This example shows that sometimes we run into problems that can only be solved by a strict collaboration with a scientific institute. It should not only be capable of conducting chemical analyses and bacteriological analyses, but should likewise proceed to rigid laboratory and field trials, which are indispensable for the solution of this type of problem.

It is very important that we should be better oriented concerning the relationships existing between aeration, temperature, organic substances, water content, and carbon dioxide production during the composting. These questions can be solved only when these various factors can be regulated at will.

To this end we have constructed an apparatus consisting of a rotary drum. This is enclosed in a heating coil, and a thermostat regulates the temperature. Gas inlet and outlet tubes make possible the careful regulation of the air. If a current of nitrogen is passed through the apparatus instead of a current of air, it is possible to produce anaerobic decomposition. In order to obtain optimum aeration, the drum may be rotated with an electric motor. The compost is thereby well mixed during decomposition. We hope to be able to solve some important problems with this apparatus.

Research projects

In closing I might mention four groups of research projects that are being studied by our international study group:

1. Analysis of compost.
2. Composting.
3. Applications in agriculture and horticulture.
4. Scientific study of basic problems.

1. In the analysis of compost, it is essential to establish standardized methods of chemical and bacteriological testing. While sufficiently exact chemical methods are known for the determination of amounts of ash, total nitrogen, and total carbon, this is not the case for the determination of the amounts of combustible carbon, of the easily decomposable organic substances, and the assimilable nitrogen. Precise methods for bacteriological investigation are also lacking. It would be very desirable if at least one institute in each country were to occupy itself with the principles of analysis applicable to compost and the development of recommended methods, and that these institutes keep constantly in touch with each other.

2. Insofar as the composting itself is concerned, many problems exist that should be solved, such as that of the duration of composting in relation to the desired content of readily decomposable organic matter. Furthermore, the question of aeration of the compost should be thoroughly studied by the analysis of the gases of decomposition. Also the inmixing of sludge is a pertinent study question, particularly as regards its influence on the course of the composting. It is clear that the product should be analyzed frequently, both before and after the composting, and that the course of the temperature should be recorded.

3. Satisfactory investigations concerning the use of compost in horticulture and in agriculture can, in my opinion, be conducted only by competent experimental stations. I wish to emphasize here that such trials should be conducted with all the strictness required, and in an objective manner, in order to protect the farmers from economically or idealistic-sentimentally colored propaganda.

For the conduct of field or laboratory trials, the State experimental stations deserve primary consideration. In no way do I underestimate the usefulness of small, planned experiments undertaken by the composting plants themselves. However, positive results so obtained should be verified by official agricultural experimental stations, before the results are released to the public and allowed to be publicized. In this respect, too, particularly concerning the establishment of a more or less standard technique of analysis, international collaboration would be very useful and desirable.

4. A scientific basis of solid facts which would allow the explanation of the favorable or injurious action of compost under various circumstances, is still often missing and, when this has been the case for a long time, imaginations have been given free play. Such investigations can be conducted only by specialists, and oftentimes a costly, well-equipped laboratory is indispensable. Besides, these studies must often be conducted over a long period of time as, for example, the investigations concerning the formation of humus and its accumulation..

Such basic investigations may therefore only be carried out at scientific institutes. In this field, international collaboration is limited, in my opinion, to the exchange of results and experiences. This would also prevent a number of institutes from working on the same problem at the same time, thus avoiding costly duplication.

I have attempted by means of a few examples to give you a view of some of the problems for investigation from our standpoint, that arise with respect to the composting of urban refuse in the Netherlands. I hope that the international collaboration envisaged in this field will bear fruit.

4. What is a good refuse compost?

(Short report presented by Director W.A.G. Weststrate at the first meeting of IRGR)

I should like to discuss this question from the practical point of view. This perhaps will be the easiest way for me to formulate my thoughts on the subject.

The reason why farmers and horticulturists use compost of domestic wastes is primarily a hoped-for increase in yield. This increase in yield may not necessarily be perceptible during the first year after the compost is applied but, let us say, in two years, it is. Even after 3 or 4 years the favorable influence of the compost is still manifest, but to a lesser degree; this may be considered, then, as a sort of supplementary advantage.

The first condition that a good compost from domestic wastes should fulfill, then, is that it directly increases the yield.

Nevertheless, this increase in yield is not always attained. If a series of trial fields are checked, there are always a few that do not exhibit positive results. In an inquiry which we made a few years ago to 100 users of compost, 84 submitted positive results; in 16 instances no increase in yield was established. This lack of increase in yield might be due to such causes as insufficient irrigation or deficient drainage. But it is also possible that the soil in question was in excellent condition, so that it had no need for lime, trace elements, or organic salts, and for this reason did not react to the addition of these substances. In this case however the compost still has a useful action, since it maintains the soil in good condition and its fertility is preserved.

Consequently there are consumers who use compost once every 5 years, to make sure that the soil does not lack trace elements, lime, and organic matter. Over the years, and particularly in times of unfavorable weather, the use of compost pays in my opinion. If it is observed that the fertility of the soil is diminishing, if deficiency diseases appear, it is my viewpoint that it is already too late. Prevention is better than cure. "Compost from domestic wastes assures a steady yield". This is a slogan dear to the producers of compost.

The second condition that a good compost from domestic wastes must fulfill is therefore that it maintain the soil in good condition, prevent the appearance of phenomena of deficiency, and contribute to the preservation of the good structure of the soil. This factor is important, as mineral fertilizers indeed raise the fertility, but do not maintain it over long periods of time.

The scientific studies teach us that the regular use of compost over a long period of time increases the fertility of the soil the content in humus of the soil increases little by little which is manifested, after a long period, say 50 years, in an increase in fertility of the soil.

Recently, when a composting station was opened at Venlo in southern Holland, the Minister of Agriculture emphasized in his speech that the care and conservation of a fertile soil for a long period of time required the active cooperation of all persons and institutions involved. A farmer cannot be required to pay out money in order that his fields may be more fertile 50 years hence. This is one of the reasons why the authorities should promote the use of compost, since the preservation of the fertility of the soil is a matter of general national interest.

Thus, what we require of a good compost from domestic wastes is:
a) that it directly increase the productivity of the soil, in any case during the first and second years;
b) that it maintain the soil in good condition, in other words, that it increase the stability of the yield;
c) that it increase the fertility of the soil if it is used regularly over a long period.

It is not difficult to enumerate all the good attributes which should be present in this type of fertilizer, but which compost effectively answers these requirements?

When we investigate this, we quickly hit upon the fact that the same compost which gives good results in one geographic region will not do so in another region. The same product used by farmers on sandy soil was highly praised, while other farmers, who used it on clay soil considered it utterly worthless. The differences in climate, in choice of crops, etc. are also determinative factors in the evaluation of a compost. For example, on the loess soils of the Netherlands, we do not use compost, because it has shown no good influence upon it. On the loess soils in France, in the vicinity of Paris, quite a lot of compost is used, and with the very best results!

Two Dutch experts have gone to France to find the reason for this difference. It stems from this, besides a few other minor intervening factors: in France it rains much less in late summer than it does in the Netherlands. In the Netherlands a second crop can be sowed and used as green manure. In France this second seeding is generally not possible because of the dryness. In our country this cheap green manure maintains the soil in good condition. For this reason, the use of compost does not give any noticeable results, while in France it is impossible to do without compost.

One other example: in light soils deficient in lime, compost generally has a favorable effect, because it contains a few percent of lime. But if the soil is rich in lime and is sensitive to an excess, compost should not be used. The beneficial effect of compost depends to a large extent upon the nature of the soil, of the climate, and of the methods of cultivation; we cannot therefore affirm a priori whether compost is good or bad. It is good under certain conditions.

I should like to consider for an instant the inverse question. What is a poor compost? What are the negative properties that can be present in a compost which make it unfit for fertilizer, or at least lower its quality? From this standpoint the need to make a compost in such a way that it does not present these negative properties is shown.

To begin, the compost should be free from pathogenic microorganisms, particularly microorganisms causing plant diseases. It should also not contain weed seeds susceptible to those diseases. Furthermore the presence of certain trace elements in excess is always injurious, because these elements may exert a toxic action. In practice this occurs when the ash has a high boron content, as is the case in some parts of Germany. In such cases the high boron content of the compost makes it less useful, or even unusable.

An excess of lime is injurious, so, although lime is useful for soils with a low pH value--one cannot generally use a compost rich in lime. These objections are justified particularly in horticulture, where the amounts of fertilizer used are generally high, resulting in an excess of lime in the soil.

We consider that the 3% of lime that Dutch domestic waste compost contains is a maximum, and we are trying to lower that content by the addition of sulfuric acid. In foreign countries, the lime content of the compost reaches up to 6% (in Munich [Muenchen] even 15%) which is certainly too high for our lands.

Too low a content in organic matter should be avoided. Compost is an organic fertilizer; its main usefulness lies in its ability to maintain bacterial life in the soil. The content in organic matter should not drop below a certain minimum. We believe that the bacterial life makes more active the influence of the trace elements, and that the bacteria play the role of buffers in relation to nitrogen, phosphorus, and the other minerals. It may be that in winter the compost contains too much ash and the content of organic matter becomes too low. In this case ashes should be partly removed by screening, or by mixing the compost from winter domestic wastes with compost from summer domestic wastes.

All these questions have still been too little studied, thus it is not yet possible to give definite figures. And if such figures were determined, they could have no validity for general purposes, but only for certain kinds of soil. The ashes, for example, would be of greater utility on heavy soils than on light soils, because they improve the soil structure.

I believe it would be very useful if the various countries tried to establish units of measurement which could be compared among them in order to establish standards applicable everywhere. Exceptions would always have to be made for certain geographic regions, but this is not a serious deterrent, if we are aware of these special circumstances.

I have not yet mentioned the impurities which so frequently lessen the value of the compost, that is, the fragments of glass and pottery, cinders, pieces of coal, and also substances that are difficult to decompose such as rubber, nylon, etc. These impurities have no influence on the value of the compost as fertilizer, but they make the compost less attractive and sometimes even unusable.

In horticulture, where the gardeners handle the soil with their hands, the glass fragments are a grave drawback. In pastures where cattle graze they are dangerous. When mowed by machine, pieces of iron and other hard substances may damage the blades of the mower. In agriculture, old nylon stockings can foul up harrows, etc.

It is relatively simple to determine the purity of compost, in comparison to the analyses necessary to determine its chemical composition. A sample of compost is sifted through a standardized, fixed, mesh, sieve. What remains in the sieve are hard indestructable components and soft components that will disappear after further fermentation. The hard substances are taken out of the residue in the sieve and their percentage of the total sample weight is determined. All that remains to be done then is to fix the maximum permissible percentage. In Holland we distinguish between horticultural and agricultural compost. It actually concerns one and the same product, the only difference being in the results of the sieve analysis. For horticultural compost we specify that one ton should not contain more than 0.5 kg of glass fragments, not more than 0.5 kg of ceramic (pottery) fragments, and not more than 5 kg of pieces of coal and of slag. The ceramic and coal fragments are determined with the help of a sieve with round perforations of 6.8 mm diameter. Iron should not be present at all. For agricultural compost the limits of tolerance are not as easy to fix, because conditions vary so from one region to the other. In any case, however, the percentages tolerated can be set much higher, say 10 times as high; that is, 5 kg of glass and potsherds, 50 kg of pieces of coal and slag per ton of compost. Here, too, it would be desirable to establish international standards. We must not underestimate the importance of the degree of purity of a compost! Over the years the consumer requirements have risen greatly. He does not wish to see his gardens or fields full of shining fragments of pottery or glass, and the mechanization of agriculture itself requires a greater purity of the compost.

What generally hinders the production of domestic waste compost the most is the uncertainty of marketing conditions. Compost must be sold during periods of prosperity and also during recessions, just like the animal manures. Farmers and gardeners always need fertilizer every year. But they will first do without the fertilizer that pleases them the least, which happens to be compost which shows the least spectacular results. Compost is generally bought only when nothing else is available, and that is wrong. This originates from the fact that the consumer prefers other fertilizers, which contain no fragments of pottery or of glass and possess a more constant composition as, for example, animal manure.

It is consequently of great interest to establish minimum requirements that a compost must satisfy in order to avoid mishaps and to give the consumer the truth, that compost is a valuable fertilizer and a means of improving the soil.

5. The research program of the Working Committee on the Management of Community Wastes (der Arbeitsgemeinschaft für Kommunale Abfallwirtschaft [AkA])

(Extract from a report by Dr. Straub, presented at the first meeting of IRGR)

Since 1950 various working groups (committees) existed in Germany which concerned themselves with the problem of domestic wastes: the Working Group of the "A.T.V.", Management of Humus; Working Group "Problems of domestic wastes" of the Public Roads Administration; Working Group "Evaluation (utilization) of Domestic Wastes" of the German Agricultural Union; Working group "Settlement waste management" of the Municipal Delegates Union.

These four groups were united in 1952 into a Working Committee on the Management of Community Wastes (AkA) and attached to the Municipal Delegates' Union. In the AkA, the representatives of cities, of scientific institutes and colleges, of agriculture, of horticulture, and of sylviculture, both scientific and applied work together, as also do representatives of viniculture. The AkA is a loosely-bound group with interests reaching out in every direction, which has a Council and a Committee of Experts for the working-out of specific problems. The Council and Committee of Experts are concerned with formulating the research problems and submitting their programs to Federal and State (or County, or Provincial) authorities, who are expert in the matter themselves, in order to obtain research grants. The Expert Committee has already made a complete list of the material available in the field of research on the disposal of domestic wastes. This voluminous document has been collected under the aegis of Professor Dr. Popel, Stuttgart, and Dr. Buck, Stuttgart, as responsible authors, and has been submitted in the form of an expert's report to the Federal Ministry and should be published by them soon. In addition, the AkA has established a far-reaching research program which may be divided into three working groups. The main subjects are as follows:

Group 1. Procedures for the treatment of domestic wastes with and without digested sludge, taking into account physical, chemical, and biological measures.

Group 2. Procedures for the evaluation of domestic waste compost in relation to planting trials.

Group 3. Possibilities for the use of composts made from domestic wastes in agriculture, the raising of fruit trees, horticulture, viniculture, and sylviculture.

In No. 4, 1956, of the publication of the Municipal Delegates' Union, "Der Städtetag", this research program was published in detail. Investigations were conducted within the sphere of this program in 1954 and a short report will be made in Information Bulletin No. 2.

6. The evaluation of the organic matter in humus fertilizers.

(From a report presented by Dr. U. Springer at the first meeting of the IRGR, and from other communications of the author)

A definite evaluation of the worth of a humus fertilizer, particularly of a commercial fertilizer, is, of course, possible only after long years of field trials, wherein, after the conclusion of the trials, the soil should be examined from physical, chemical, and biological viewpoints (retention of carbon and nutritive substances, structure of the soil, absorption capacity, microflora, microfauna, etc.). However, the possibility may exist of deciding the question by analytical methods, whether in a given case a humus fertilizer is present and whether in particular the qualities that must be present in an all-around commercial fertilizer have been fulfilled. Also, certain judgments may be made on the basis of laboratory investigations concerning the value of the fertilizer under consideration (humus with nutritive elements or those tending to enhance the accumulation of humus, fresh or aged humus substances, stability, binding power, ability to retain the various elements, etc.). However, the fact must be taken into account that the value of a humus fertilizer varies according to the dynamics of the soil to be fertilized. Consequently for light soils a fertilizer that increases the humus content thereof is in general more suitable than such a fertilizer would be for heavy (clay) soils and the opposite holds true for the said heavy soils.

A commercial humus fertilizer should be required to have a content of at least 25% of active organic substance, consisting of nutritive humus and long-lasting humus (accumulative humus). The active organic substance may be defined as the difference between the total organic substance and the inactive substance (humus carbon). The total organic substance is usually estimated from the loss on combustion, since a calculation on the basis of the estimated carbon-value is not generally possible by reason of the variable conversion factor. However, one can circumvent this difficulty by indicating the corresponding values for the organic substance or for certain fractions of the organic substance simply as carbon-values.

If a fertilizer contains soluble salts which volatilize during combustion, probably being also decomposed (ammonium salts, nitrates, urea, etc.) we eliminate these salts with a neutral salt solution (K_2SO_4; or better, because of its precipitating action, $CuSO_4$, or its equivalent) and determine the loss from combustion of the residue. The soluble substances can be determined in the extract by familiar methods. The amount of pure organic substance might possibly, therefore, also be expressed as the difference between the total loss from combustion and the calculated amount of salts. Generally in the extraction of salts a certain loss of organic substances cannot be completely avoided.

By inactive substances we mean essentially those that do not have humic acid and those that are not carbohydrates; thus, the particles of carbon insoluble in an alkaline medium, lignohumins, phlobaphenes, technical lignin, which are the more or less carbonized products of the saccharification of wood, and other products foreign to the soil (rubber, rotten leather, plastics, etc.).

The inactive substance (humus carbon) may be determined as follows:

First of all the bases to which the humus substances are bound are eliminated. For this purpose, 1 to 5 gm of the fertilizer is heated in an Erlenmeyer flask with 100 ml of 5% HCl at about 60° C for a half hour, and finally washed practically free of chloride in a centrifuge. Then the residue is boiled in the Erlenmeyer flask with a funnel added, for one hour, adding 100 to 200 ml of 0.5% sodium hydroxide (extraction) and is washed in the centrifuge until such time as the centrifugate becomes colorless. In the alkaline extract the humus substances are precipitated by the addition of 20% HCl, filtered through a porcelain filter, and washed nearly free of chloride, then dried at 105-110° C, weighed, and calcined and weighed again. The difference in the weights corresponds to the humus substance which in turn is made up of a mixture of true humus substances and of humus substances still in the preliminary stage of formation; whereas a small portion of substances of low molecular weight (fulvo acids /fulvene = C_6H_6 = methylenecyclopentadiene/) do not precipitate.

The residue remaining after alkaline extraction is thoroughly mixed in a centrifuge tube (agitator?) with 10 ml of 80% sulfuric acid, washed afterwards with 150 ml of water in a round flask, and hydrolyzed for 5 hours in a reflux refrigerator. The cellulose and polyoses (hemicelluloses) thus enter into solution. The residue is now filtered through a Gooch filter, washed free of acids, dried at 105° C, weighed, calcined at about 1000° C, and weighed again. The difference in weights corresponds to the amount of humus carbon.

In the hydrolysate, the sugar may be determined and thereafter multiplied by the factor 0.9, to calculate the total amount of carbohydrates (cellulose and hemicelluloses). It is to be remembered that a small portion of the hemicellulose has already gone into solution during the acid pretreatment.

Further literature on this subject:

U. Springer. in Mitteilungen d. Verbandes D. Landw. Untersuchungs- und Forschungsanstalten (Reports of the Union of German Agricultural Investigational and Experimental Stations) No. 1, 1954, pp. 6-8.

U. Springer and A. Wagner. On the analysis of organic substance in humus fertilizers. Landw. Forschung. (Agricultural Research) Vol. 7, No. 3, 1955.

7. Reprints received by the secretary.
(Sent on request, as long as the stocks last, to interested persons.)

(Abstracts)

Hahn, U. (1955) Die Müllverwaltung in der niederlandischen Forstverwaltung
(The use of compost from domestic wastes in the Forestry Administration of the Netherlands.) No. 91 of the "Berichte über Studienreisen in Rahmen der Auslandshilfe der USA" (Reports on Study Trips in the areas of Foreign Aid of the Union of South Africa). 28 pages. Publ. Kommentator Co., Ltd., Frankfort-am-Main.

In the first part of the report, the author briefly reviews the general situation in agriculture and sylviculture, as well as various Dutch theories concerning the value of domestic waste compost. In the second part, he briefly describes the effects of domestic waste compost on Dutch soils. The third part is devoted more specifically to the use of composts of domestic wastes in the Dutch forests. The various types of urban refuse are analyzed in detail (raw domestic wastes = garbage, etc.; raw domestic wastes plus fecal matter; fermented wastes = sludges), their method of use and their effect upon the forest soil. In the fourth part (practical application in Germany of the examples of the accomplishments seen by the author in the Netherlands) it is concluded by the author that the Dutch methods probably could not be applied in Germany without first undergoing certain modifications. The chief reason he gives for this is that the economic structures of the two countries is not the same, so that the domestic wastes are not of the same type.

Rossberg, H. (1956). Das neue Kompostwerk in Duisburg-Huckingen. (The new Compost station in Duisburg-Huckingen) Reprint from "Stadt un Hafen" (City and Port) No. 10, 2 pages.

A composting plant of the Dano type, being built in the heart of southern Duisburg, is to have a daily capacity of about 200 cubic meters of raw domestic wastes, and will compost the refuse of a region having 140,000 inhabitants. The plant is being built on the grounds of the sewage treatment plant which facilitates the addition of digested sludge. The sludge is pumped from a digester to the inlet of a biostabilizator by a small pump. When the gas production of the digester has increased sufficiently, the excess gas is used to generate electrical energy, thereby reducing the operating costs of the composting plant. The plant will probably be put into service by the spring of 1957.

Steigerwald, E. and Springer, U. (1953). Weitere Versuche mit Müll, Müllkompost, and Müll-Klärscheim-Komposten 1950-1952. (Further experiments with refuse, refuse compost, and composts of refuse and sludge.) Reprint from the "Zeitschrift für Pflanzenbau und Pflanzenschutz" (Journal of Plant culture and Plant protection) Vol. 4, No. 5, 27 pages.

On the basis of the results of a total of 42 large-scale trials between 1949 and 1952, the authors were able to reach the following conclusions:

(Abstract of conclusions):

A. Experiments with fresh refuse.

1. Direct application of fresh domestic wastes increases the yield only of plants which flourish on such wastes.

2. Prerequisites for a favorable effect of fresh wastes are: that they be well mixed into the soil and that the moisture be sufficiently high.

3. Plants that are sensitive to domestic wastes tolerate direct application of domestic wastes poorly and react with definitely reduced yields.

4. This diminution of yield exhibited by waste-susceptible plants when such waste is freshly applied may be avoided by giving the plants plenty of water.

5. The direct application of fresh refuse gives better results if applied in the fall than in the spring.

6. Certain plants such as carrots react to fertilization with fresh domestic wastes by producing more leaves and stems, but not larger or better roots.

7. An application of fresh domestic wastes acts favorably upon the subsequent crops also.

8. With fresh refuse, a good balance in content of nutritive substances is obtained, apparently through the differences in solubility of the individual nutritive substances.

9. A supplementation of the nutritive substances in fresh domestic waste application should be performed by the addition of all the basic nutritive elements, not just one of them.

10. An appropriate amount of fresh domestic waste for addition to the soils of the Munich area comprises an amount of 9 to 12 hundredweights per are. (Ed. note: Presumably the common hundredweight of 112 lbs. and the "are" is 100 sq. meters or 0.025 acre.) This fertilization will give the following results:

   a) during the first year in the case of plants which flourish on refuse, the domestic wastes applied in the fall caused an increase in yield of 20-25% and more.

   b) during a period of 4 years by alternating crops flourishing on domestic wastes with those sensitive to it, we obtained an average increase in yield of 14%.

11. It is recommended that cultivation of plants sensitive to fresh domestic wastes be not attempted until 2 or 3 years after its application.

12. Fresh domestic wastes constitute an excellent source of heat and protection for hotbed crops.

B. Experiments with compost made from refuse.

1. Composted domestic wastes have given higher yields in each trial series than did fresh domestic wastes.

2. Composted domestic waste is tolerated well in small amounts by plants sensitive to fresh wastes.

3. Higher amounts of composted domestic wastes did not increase the yield of plants susceptible to domestic wastes.

4. The subsequent crops after a crop had been harvested following the application of refuse compost, were often better than the first crop, particularly in the case of plants susceptible to domestic wastes.

5. A special influence of refuse compost on the development of leaves and stalks in such crops as carrots could not be observed, such as had been found in the application of fresh wastes.

6. A concomitant composting with fresh domestic wastes plus superphosphates had very good results.

7. As the most effective amounts of fertilizer, the following may be recommended for mixtures of domestic waste and superphosphate:

a) for plants that thrive on domestic wastes, up to 18 hundredweight per are of composted domestic wastes, and 120 kg per are of P_2O_5 as superphosphate.

b) for plants sensitive to domestic wastes, 3 hundredweight per are of composted domestic wastes and 120 kg per are of P_2O_5 as superphosphate.

8. With these amounts of fertilizers, the crop increase with plants flourishing on domestic wastes was more than 30%, with plants sensitive to domestic wastes this increase was approximately 20%.

C. Experiments with compost made of refuse plus digested sludge.

1. This waste-sludge compost gave better results than fresh wastes or composted wastes.

2. The most advantageous and most economical proportions of this mixture of waste and sludge were adjudged to be: two volumes of screened fresh domestic waste and one volume of dense digested sludge.

3. In contrast to fresh domestic wastes, fertilization with the waste-sludge mixture in the spring yielded better results than when the same was applied in the fall.

4. The yields increased with the amount of waste-sludge compost applied, for waste-susceptible as well as for waste-loving plants.

5. Even the amount of 27.5 hundredweight per are of this compost further increased the yield.

6. This fertilization resulted in the attainment of increases in yield of an average of 45%.

7. The subsequent effect of a fertilization with this sludge-waste combination upon second crops has been excellent.

In all experiments with fresh domestic wastes, composted wastes, and waste-sludge composts applied to the land, a remarkable loosening of the soil was observed to occur which was the more noticeable the greater the amount applied. Thus, at the end of September and the beginning of October 1952 when the rains were very heavy, the harvest of carrots and beets that resulted immediately thereafter showed that the carrots and beets from treated land brought with them much less soil than did the ones from untreated land. The observed favorable action of fresh wastes, composted wastes, and waste-sludge composts on the soil structure will be further investigated and verified by precise measurements.

The study of the influence of domestic wastes or of compost of mixed wastes and digested sludge on the humus content of the soil (terrain formed by filling) has shown that this results in a considerable increase in carbon content, but that the increase in active organic substances, particularly active huminic substances (permanent humus), is considerably less marked, because the composts contain relatively little of these substances. Nevertheless it is interesting to note that the carbon contained in domestic wastes employed during the trial period of three years has shown great resistance to the action of biological decomposition.

We ascertained that the compost made of domestic wastes and digested sludge resulted in a definite increase in huminic substances and other compounds capable of resistance to decomposition. Therefore such a compost is to be preferred to simple fertilization with domestic wastes, especially if the soil is poor in humus.

Thus it may be concluded that:

a) The sieved fresh domestic waste, for certain crops and under certain circumstances, has resulted in an increased yield which is sometimes very extensive.

b) Compost made of screened domestic wastes has shown itself to be definitely superior to fresh wastes, and may even give good results with crops usually sensitive to the action of such fresh wastes, if used only in small amounts.

c) The compost made from domestic wastes and digested sludge, however, brought about the greatest increase in yield.

Arbeitsgemeinschaft für kommunale Abfallwirtschaft (AkA) 1954: Probleme der Siedlungsabfallwirtschaft (Problems of waste management.) Memo on the question of the evaluation of sludge and domestic wastes.

This voluminous memorandum contains the following papers:

(Titles translated from the German)

Popel, F. Investigations in the field of the conversion and utilization of community wastes.

Kumpf, W. Economics of community waste and the economy of the general public.

Herrmann, W. Survey of the conversion methods for community refuse.

Straub, H. The manufacture of compost from activated sludge and domestic wastes by the Baden-Baden process.

Stiegerwald, E. The use of community wastes in horticulture and agriculture.

Klenk, E. Domestic waste compost and its significance in viniculture.

Kirschfeld, P. The use of community wastes in forestry (sylviculture).

Cosack, J. The use of community wastes in the management of Dutch forests.

Arbeitsgemeinschaft für kommunale Abfallwirtschaft (AkA): Rules for the agricultural utilization of compost from community domestic wastes.

We shall come back to some of these very interesting reports in a later number of our information bulletin.

Rohde, G. (1954/1955). Kompostierung der Stadtabfälle (Composting of urban domestic wastes). Reprint from Wissenschaftliche Zeitschrift der Humboldt-Universität zu Berlin. Mathematics and Science Series No. 5, 4th Year, 18 pages.

The author has tried to develop the "natural composting" method and expounds on its principles. His main theme is the further development of the famed Indore method and consists of natural composting in windrows 3 meters wide by 1.5 meters high, in semi-circular piles with aeration channels. During 1954 the author produced 37,000 cu. meters of compost from the domestic wastes of Greater Berlin (domestic wastes, street sweepings, pig feces, digested sludge).

Allenspach, H. (1956). Untersuchungen über die gemeinsame Aufbereitung von Klärscham und Kehricht (Investigations on the common treatment of digested sludge and rubbish). Reprint from Plan No. 3, Publication of the Swiss Association for the Protection of Waters.

In Switzerland the problem of simultaneous treatment of sludge and rubbish gains ever greater interest, particularly because a 1955 regulation regarding the sale of milk has placed certain restrictions on the use of activated sludge as a fertilizer. The author briefly describes experiments in the concomitant composting of sludge and domestic wastes, as they have been conducted to date at the composting plant in Rüschklon (District of Zürich). The following important questions might be answered:

1. May sludge be added in the case of decomposition of domestic wastes in a chamber at the plant site? If so, may we air-dry the sludge so that it is possible to treat the entire amount of refuse and sludge from a given community?

2. How can the product of this fermentation chamber be altered so as to make compost useful for various purposes?

3. What are the properties of this compost from digested sludge and how do the crops react to it?

By the concomitant treatment of the two kinds of waste products, it is hoped to achieve not only an improvement in the quality of the compost of domestic wastes, but to thereby eliminate the disadvantages of using activated sludge (danger of spreading noxious weeds, pathogenic microorganisms, etc.).

Braun, R. (1956). Das Kehrichtproblem in der Schweiz (The Rubbish Problem in Switzerland). Reprint from "Plan" No. 3. Publication of the Swiss Association for the Protection of Waters.

The author points out that in Switzerland the methods used for treatment of wastes are largely unsatisfactory. Not only on aesthetic and hygienic bases, but also with regard to the menace to surface and underground waters, should this situation be remedied. While in foreign lands the question is judged rationally from the point of view of the public economy and it is sought to treat domestic wastes by transforming them into a product beneficial to the soil, in Switzerland it is sought to eliminate these wastes as cheaply as possible, without thereby causing injury to mankind or to animals, to agriculture or waterways. The possibilities of the disposal of domestic wastes and the evaluation of uses for domestic waste compost under Swiss conditions are briefly discussed.

8. Communications.

All the reports presented on the occasion of the International Symposium on the Present Problems of the Removal, Treatment and Utilization of Domestic Wastes held in July in the EPE (ETH) at Zurich, were published in French in the Swiss Revue d'Hydrologie, vol. XVIII? (XVII?) No. 2, Birkhäuser, Publ., Basel.

The German texts of these reports will be published later in the journal "Das Gas- und Wasserfach" (R. Oldenbourg, Publ., Munich).

In order that we may fulfill our duties as an information center as we are supposed to do, we ask all the experts and specialists to do us the favor of sending us, as they appear, their reports and further publications on research results, the construction of new installations, and experience acquired in the course of conducting such business, as swiftly as possible.

Further copies of the Information Bulletin can be obtained from the Secretary, also the reprints herein mentioned.

INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)

Information Bulletin No. 2

April 1957

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1. Meeting of July 4-6, 1957 of the Working Committee on the Management of Community Wastes (der Arbeitsgemeinschaft für kommunale Abfallwirtschaft) (AkA) at Düsseldorf.

The working committee of AkA has organized the 4th working session, choosing Düsseldorf as the site because the third composting plant in Germany is being put into operation in the immediate vicinity, at Duisburg. The IRGR will participate in this working session. IRGR was founded in 1955, under the presidency of Dr. O. Jaag, and has its headquarters in Zurich. It is made up of national study groups from among the countries of Western Europe.

Although the problems of urban sanitation may be different in the various countries, those concerning domestic waste disposal are largely alike. An exchange of views on an international scale is therefore desirable. Such meetings will broaden our knowledge of operational techniques and of biological and agronomical aspects of the problem, especially when participants include eminent French, German, Dutch, Belgian, and Swiss specialists. Methods of refuse disposal, particularly of domestic refuse, have been developed considerably in recent times. The institutes of agronomy and sylviculture continue to conduct interesting investigations on which results will be presented during the working sessions at Düsseldorf.

Trips are planned to Duisburg-Huckingen and to the "Zonser-Heide" where participants may visit composting plants and see experimental crops treated with refuse composts. Visits are also planned to the modern sewage treatment plants in the Ruhr.

2. Program of the AkA Meeting, July 4-6, 1957.

Thursday, July 4, 1957. Legislature Assembly Chambers.

9:00 A.M. - Opening of the session. Welcoming speeches in the name of AkA, IRGR, the municipal authorities of Düsseldorf, and the State and Federal Governments.

9:30 A.M. - Main Address No. 1. Doctor of Engineering Pöpel, Technical Institute, Stuttgart, "Basic questions on the treatment of urban wastes."

10:30 A.M. - Main Address No. 2. Doctor Springer, Bavarian State Horticultural and Plant Protection Institute, Munich, "Feasibility of application of tests for the evaluation of refuse composts."

11:30 A.M. - Brief reports accompanying Main Address No. 1.
1. Chief Public Works Engineer, Doctor Straub, City of Baden-Baden.

2. Engineer Allenspach and Municipal Engineer Horgen, Switzerland.

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3. Doctor of Science Braun, Zurich, Switzerland.

1:00 P.M. - Luncheon - Restaurant of the Legislature.

2:30 P.M. - Brief reports accompanying Main Address No. 2.

1. Agricultural Engineer De Groote, State Horticultural Research Institute, Ghent, Belgium.

2. Discussions of the first and second main themes.

4:30 P.M. - State Forest Commissioner Cosack, Forestry Division of Düsseldorf, "Introduction to a survey of sylvicultural experiments at Zonser Heath."

5:00 P.M. - Main Address No. 3. Engineer B. Teensma, Chief, Agricultural Section of V.A.M., Amsterdam, "The use of urban refuse compost in the Netherlands." Discussion.

8:00 P.M. - Social gathering.

Friday, July 5, 1957. Legislature Assembly Chambers.

8:30 A.M. - Main Address No. 4. Doctor Sauerlandt, Institute for Soil Management, Braunschweig-Völkenrode, "Refuse composts and their influence on soil and crops."

9:30 A.M. - Brief reports accompanying Main Address No. 4.

1. Dr. J. Keilling, National Agronomic Institute, Paris.

2. Dr. F. C. Gerretsen, Agricultural Experiment Station, Soil Culture Institute, Netherlands.

3. Discussion.

12:00 N - Luncheon - Restaurant of the Legislature.

2:00 - 6:00 P.M. - Visit to the sewage treatment and composting plants at Duisburg-Huckingen with introductory remarks by Chief Architect Rossberg of Duisburg.

Saturday, July 6, 1957.

8:00 A.M. - Visit to experimental forestation area treated with refuse compost in Zonser Heath near Neuss under the guidance of State Forest Commissioner Cosack, Forestry Division of Düsseldorf.

1:00 P.M. - Closing of the sessions in Dusseldorf. Saturday afternoon -- Visits to the sewage treatment plants in the Ruhr region. The program will be announced at Dusseldorf. (Ed. note: Additional information is given regarding registration, fees, publication of papers in a proceedings, excursions, and a program for the ladies -- not included here.)

3. The Opening of the New Compost Plant at Almelo (Netherlands) by Engineer B. Teensma, Amsterdam.

The new compost works at Almelo began operations in October, 1956. The plant operates according to the grinding (Raspel) system that is already in use in the Dutch composting plants at Vlissingen, Schiedam, Sneek, and Delft (Ed. note: also called the Schiedam process). The Almelo works is also equipped to mix activated sludge with refuse.

The following is an extract from the speech made at the dedication of the plant by Director General A. W. van der Plassche, Netherlands Ministry of Agriculture:

The Ministry of Agriculture of the Netherlands has long shown great interest in refuse compost production because it is necessary to consider all possibilities assuring an appropriate livelihood for the farmers and horticulturists. The development of productivity by use of remedial measures is an important role in a positive agrarian policy. Great possibilities still exist in Holland in soil improvement and greater productivity by farmers and gardeners. The Netherlands Government, therefore encourages the use of composts of refuse and other materials valuable for improving the soil.

The Ministry of Agriculture not only promotes this principle but has made extensive financial contributions in the past 25 years for the conduct of research and practical studies in the field of the preparation of compost. The Government has used 10 million Gulden (about 2½ million dollars) of Marshall Funds for the promotion of this work.

Large quantities of compost have been made available to agriculture and horticulture because of this support. It has also been possible to compare different composting processes from the technical, organizational, and economic viewpoints.

Thus, a plant operating according to the "Van Maanen" system was installed at Mierlo, similar to the first plant using this process at Wijster, but in modern form. In Schiedam, an experimental plant has been using the "Raspel" system (Ed. note: the "Raspel" is a type of grinder). The installation of a whole series of new composting plants has been made possible due to the fact that communities receive Government credit without paying any interest when they submit completed plans for compost plant construction.

The Schiedam experimental station started operating in October, 1[illegible], following a similar station at Vlissingen in 1950. Plants using the Raspel method were opened at Sneek (1954) and Delft (June, 1955). The Mierlo plant began producing compost for the eastern portion of the province of North Brabant in the fall of 1955. In May, 1956, the first Dano plant was opened at Venlo, and two similar plants were built at Enschede and Baarn.

Construction of these plants represents the end of the first stage, since the credit of 10 million Gulden has now been exhausted. Nevertheless, two other communities, Arnheim and Hengelo, have decided to build Raspel composting plants with self-financing. Thus it can be seen that various composting methods have been tested and compost production has been distributed to a certain extent throughout the country. This is important because, in shipping and distribution, decentralization keeps transportation costs down. We can assert that both horticulturists and farmers are showing increased interest in compost as is demonstrated by increased demand and sale of compost.

Good collaboration between producers of compost and consumers is necessary. Besides the price, the question of quality is important. If the price of compost is reduced for any reason, it should not be at the expense of its quality.

4. The Use of Refuse Compost in Viniculture by Director Ernst Klenk, State Educational and Experimental Station for Viniculture and Horticulture, Weinsberg bei Heilbronn, Germany.

Foreword by the Secretary: A series of conferences and discussions on the utilization of compost, a very real problem at present, was established at the Technical College at Zurich under the presidency of Dr. O. Jaag and within the scope of the Hydrobiological Commission of the Swiss Association of Natural Science.

Although the use of refuse has nothing to do with hydrobiological research, the problem must be placed here with regard to its aspect of pollution of our waterways, as all means must be considered to bring an end to the ugly piles of wastes so injurious to our rivers, lakes, and underground waters. Only conversion of refuse to compost is considered as a means of cleaning up such conditions in many instances, particularly in medium-sized and small communities. However, such composting can only be considered in proportion to the demand for the compost thereby attained.

Director Klenk gave a very interesting survey of the use of refuse compost in viniculture based on his ten years of experience. A lively discussion followed with representatives of the federal agricultural and experiment stations participating. A representative of the market gardeners' union urged the promotion of the manufacture of such compost in Switzerland by emphasizing the difficulties encountered by market gardeners in obtaining compost, an absolute necessity for their industry.

Although conditions in Weinsberg are not entirely comparable to those in Switzerland, particularly with respect to soil conditions, it is nevertheless urgent that similar experiments be made in Switzerland. The problem is not only one of developing the culture of grapes, fruits, and vegetables, but also of developing markets for the utilization of refuse compost. Therefore, the federal experiment stations at Wädenswil and Zurich-Oerlikon have already stated their intention to try a large-scale experiment with refuse compost in viniculture in Eastern Switzerland.

We give below some extracts from the paper of Director Klenk:

Generalities:

The question of the addition of humus to the soil has as great an importance in almost no other form of intensified agriculture as it has in viniculture. By reason of modern techniques of farming which require wide spacing of plants and the constant working of the soil, the humus is rapidly consumed, especially that of the steep slopes which are strongly exposed to sunlight. There are also no remains of roots in the soil as in the case in crop rotation in agriculture.

In only rare instances can use be made of a mulch or green manure in viniculture, as has been done frequently in growing fruit trees. Viniculture is generally carried out in a dry climate, and the natural precipitation is insufficient to permit the concomitant cultivation of grasses, particularly on steep slopes. A few projects have been conducted where an irrigation system was available, with which the distribution of water could be regulated. Besides, this kind of concomitant cultivation of mulch or green manure poses a whole series of problems in viniculture, e.g., the species to be planted, the spacing of the vines, the fight against parasites, the danger of frost, etc., so that it can come under consideration in our intensive viniculture only rarely as a source of needed humus.

Stable manure is no longer available in the amounts that it was formerly as a source of organic fertilizer. Every responsible manager who wishes not to rob the soil and wishes to prevent the catastrophic effects of erosion following a deficiency in humus, must consider the addition of the best kind of humus to the soil in addition to the incorporation of the required inorganic nutrients.

Refuse compost offers a valuable and cheap source of humus in the vicinity of large cities. Cities must spend large sums to remove refuse and the useful and valuable substances it contains are lost if the materials are not composted. The Federal Educational and Experimental Station for vini- and horti-culture at Weinsberg has conducted experiments along this line over the last 10 years and the results may be of interest.

Compost as an economical source of humus:

Although successful attempts had been made prior to World War II in the preparation of compost from domestic refuse, particularly in the Netherlands and Denmark, it was only slowly introduced into Germany. Germany's constantly growing cities have increasing difficulty in the disposal of refuse. Underground waters are constantly menaced by pollution. The utilization of these wastes in agriculture is a solution which comes up almost automatically. It remains only to find a process of transforming these wastes into valuable humus which will guarantee safety to health and also will be economical.

Domestic refuse undergoes decomposition and transformation of the organic substances into nutritive humus and permanent humus, liberating considerable heat in the process. The problem consists of regulating the decomposition process by providing aeration and adequate moisture in such a way that the organic components are not totally decomposed. A relatively high temperature is required, at least at the beginning of decomposition, in order to kill the pathogens present in the refuse.

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We know that earthworms engage in the transformation of organic substances to permanent humus contained in the excrement. In addition, other arthropods and microorganisms take part in the transformation of wastes into humus. Intense activity of the microorganisms has been observed in the composting plant at Weinsberg. The summer urban refuse, together with other organic wastes, are at present transformed into "high-grade" compost.

Raw materials for composting:

As summer urban refuse is low in ashes and rich in organic substances, it is particularly well suited to composting. Yet the organic content is still not high enough to make a high quality compost. Therefore, the addition of organic material such as activated sludge is to be recommended, preferably dried sludge. It has been observed at Weinsberg that, if liquid sludge is mixed with refuse, aeration of the compost heaps is insufficient and, as a result, an insufficient transformation of organic matter to humus results.

Costs of composting urban refuse:

Composting-installations must be so planned that the compost, according to its value, finds buyers without excessive transportation costs. Production costs at Weinsberg are now about 6 German marks per cubic meter of refuse compost. Breakdown of cost figures are:

Transportation - 8%; composting - 44%; screening the compost - 32%; removal of debris 6%; machinery costs - 7%; interest on capital 3%.

The production costs could be reduced by further mechanization of composting and screening operations. At such a price the product is far cheaper than any other purchasable organic fertilizer and concomittantly the valuable materials are returned to the soil.

The effects of compost in viniculture:

Soil fertility is a function of its humus content, the clay (loam) humus complex regulating all processes in the soil which act for the maintenance and enhancement of its biological activities. The water content of a soil is best regulated in a soil rich in humus. Humus enables the soil to hold a good deal of water and to release that moisture slowly. A soil poor in humus readily forms a hard crust which reduces the capacity to absorb water and increases the risk of erosion by rains, particularly on the steep slopes in viniculture.

We have shown in many trials that a soil containing a good deal of compost has a large water-holding capacity. In parallel trials on a steep slope, two adjacent areas, one treated with compost and the other with stable manure, both showed a 40% increase in water absorption capacity. After many heavy rains (up to 70 mm. in 20 minutes), the area treated with stable manure showed occasional deep gullies cut by the water, while the area treated with compost showed no such runoff damage. On the basis of these favorable results it was possible to alter the contours of a steep slope (50% inclination) so that the many little terraces could be eliminated and the whole area cultivated mechanically, considerably reducing the cost of operations. Next year this method of using compost will make possible the use of steep slopes in the vineyards around Wurttemberg which could not heretofore be used because of extensive erosion; and the method will doubtless find application in other areas also.

As the soil water content is best regulated by compost, so another advantage of the use of compost is the favorable influence on the retention of heat by the layer of air adjacent to the soil. Thus, in the areas of Weinsberg treated with compost, better maturation and soundness of grapes occurred, permitting harvesting to be put off longer.

In a further example, comparative studies between compost and horse manure, conducted from 1952 to date at the "Limberger" vineyards, gave interesting observations. The Limberger reacts, as is known, very sensitively to unfavorable weather during the blossoming period which results generally in more or less severe blossom shedding. The harvest results showed not only a considerable increase in quantity in the compost-treated tract, but also an increase in quality. The increases in yields from the Limberger vines were as follows:

	1952	1953	1954	1955	1956
Quantity	7%	11%	13%	25%	30%
Quantity plus quality (Kg. of sugar)	4%	20%	18%	24%	34%

In comparable trials at the "Trollinger" vineyards, this steady increase in yield did not result but, in the year of compost application (2-year rotation with fertilizer), more or less greater increases in yield occurred:

	1952	1953	1954	1955
Quantity	3%	16%	4%	11%
Quantity plus quality (Kg. of sugar)	-	6%	1%	6%

In addition to general climatic conditions, almost no other plant is as sensitive to soil conditions as the grapevine. The soil is placed in the best chemical, physical, and biological condition by the use of compost. Proof of this lies in the comparison of yields obtained from trial plots treated with compost as compared to those treated with manure. Also known is that in a soil rich in humus the addition of mineral fertilizers has much greater effectiveness than on soils not treated with humus. Moreover in the former, the mineral content may be greatly increased without the usual diminution of growth and yield. The mineral nutritives in refuse compost are of little interest because they can be bought cheaper in the form of commercial fertilizer. Yet compost should have a goodly portion of nutritive and permanent humus which form the key figure in the complicated action of the many reciprocal changes between soil and plants.

The time of application of compost is important. Experiments indicate that fall application is more favorable than spring. Besides the operational economy, fall application holds the winter rains better and moisture is then available to the vines in the spring. Newly prepared tracts should receive 2 to 3 cu. m. of refuse compost per are and, then alternately refuse compost and higher grade compost at the rate of 0.5 to 1 cu. m./are. A new series of trials has been started to determine the most favorable application rate for compost in which we are using known composts in three amounts in collaboration with AkA.

Transportation of compost results in a savings over that of horse manure since horse manure has about 70% water and compost only 30%.

Summary:

When large cities are located near to a viniculture area, refuse composting should be weighed as having a two-fold benefit -- to both the community and agriculture. The choice of process for refuse-sludge composting depends on local conditions. It is difficult to recommend anything more specifically as there is no one method applicable to all situations.

5. Composting and the Use of Refuse Compost in the Netherlands.

The compost (Stichting "compost") working group in Amsterdam, included in our IRGR (address: Jac. Obreachtstraa 67, Amsterdam) has published a richly illustrated booklet under the title "The Manufacture and Use of Urban Domestic Waste Compost in the Netherlands." This brochure, published in the Dutch language, can be obtained from Stichting Compost. We present a short summary.

Introduction (p. 3): The Director-General of the Ministry of Agriculture of the Netherlands emphasizes that the maintenance and development of soil fertility is one of the most important problems of our time. From a study of the problems the following conclusions can be drawn: soil destined for cultivation should be enriched with humus; this in turn has resulted in an increasing interest in urban refuse as a possible source of organic fertilizer. The Dutch government made available a considerable sum from Marshall Funds for study of the problem besides creating a group -- "Compost" -- charged with developing methods for composting urban wastes and studying possible uses for the compost. This publication gives a succinct survey of the activities of the study group and of the Netherlands efforts in the field of composting and the use of composts.

Chap. 1 (p. 4): Our arable soil is the keystone to our existence. This chapter concerns the important role of agriculture in the productive economy of the Netherlands. Agricultural products take up a considerable portion of goods exported and are also the raw materials on which a great part of Dutch industry is dependent. Agricultural production costs are rising and competition with other countries grows sharper. The only possibility of lowering production costs is to increase land productivity. Fertility of soil must be given full consideration and all possibilities for improvement given play.

Chap. 2 (p. 7): The term "fertility of the soil" is analyzed and chemical and physical fertility are distinguished. The former is expressed as the amount of nutritive substances present in the soil, the capacity to retain these substances, and their proportionate distribution between solid, liquid, and gaseous substances in the soil. The latter is determined by the size of pores and the proportion of small pores which hold water to large pores which hold air. Pore volume is largely dependent on soil structure, the ideal being designated as crumbly or friable. A good stable structure depends on biological activity which can only be created and maintained by the regular application of organic fertilizers. Biological activity consists of the concomitant efforts of a large number of living organisms (earthworms, insects and their larvae, molds, algae, actinomycetes, bacteria, etc.) all of which require organic matter for sustenance. To maintain soil fertility, both organic and synthetic fertilizers should be used, the synthetic fertilizers for maintaining chemical fertility, organic ones for maintaining physical fertility. Maximum yields can only be obtained when the fertility of soil is maintained by the presence of these two kinds of fertilizers.

Chap. 3 (p. 12): Diminution of soil fertility is marked by reduced yield. Exhausted soils are unstable and easily eroded. Agricultural practices which result in erosion and soil exhaustion will, in time, transform the region into uninhabitable desert. Erosion is a serious problem in the United States, Central and South America, India, Africa, and other lands. Erosion has had a greater influence on the fate of mankind than wars. Maintenance of soil fertility is a problem of great importance to all humanity.

Chap. 4 (p. 14): Holland is densely populated; only 0.23 hectare of arable land is available per capita. Holland must produce as much as possible with this limited amount of land and increase production to meet population increase. There is a remarkable intensification of agriculture. Stable manure and compost were the only fertilizers formerly available and the fertility of the land was maintained at a high level with these. Supply became insufficient and in 1900 commercial fertilizers became available. Yields increased and almost all "Oedland" (chemically poor soil) was rendered cultivable. Farmers lost interest in organic manures. Refuse compost became almost unsalable and the advantages of good preparation of stable manure have been forgotten.

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It was recently realized that, although chemical fertility of the soil was markedly increased by chemical fertilizers, the physical fertility has been declining. This discrepancy is particularly noticeable in the light soils of Holland. Harvests can no longer be increased in Holland by artificial fertilizers alone, but they can be by increasing physical fertility through use of organic fertilizers.

These symptoms show the decline in physical fertility of soil: 1) Increasing wind erosion; 2) Decreasing efficiency of synthetic fertilizers; 3) Increase of deficiency diseases in crops, particularly those due to lack of trace elements; 4) Increased susceptibility of crops to dryness; 5) Increased mechanical force required to work the soil; 6) Increased susceptibility of crops to parasitic root diseases; 7) Diminished certainty of crop returns and greater dependence on favorable weather. It is now recognized that more organic fertilizers should be used in Holland and the interest in refuse composting is increasing.

Chap. 5 (p. 26): This chapter describes the three main processes of refuse composting: the Van Maanen (V.A.M.), the Raspel (Schiedam), and the Dano processes. The compost study group has the following tasks: 1) Analysis, research, and consultations in the complete field of refuse collection and disposal by composting; 2) Promotion of the use of refuse compost for soil improvement; 3) Promotion of the construction of composting plants. In Holland today more than 25% of all urban refuse is being turned into compost and the percentage is increasing.

Chap. 6 (p. 33): Average analyses of Dutch refuse compost are given and action of some of its components as well as its total effect on crops and soil are discussed.

Chap. 7 (p. 43): The authors make recommendations with regard to quantity and quality of compost best suited for: arable lands, pastures, sports arenas, horticulture, forestry, chicken ranches, pig farms, and for the rebuilding of waste lands.

6. Abstracts of reprints received at the Secretariat.

a. Stiegerwald, E. 1956 - Refuse-Sludge Compost for Soil Improvement and Fertilization. Reprint from: Praktische Blätter für Pflanzenbau and Pflanzenschutz. No. 6, 210-17, Bavarian Agricultural Publ., Munich 3, Germany.

Abs. The Bavarian Institute for Plant Culture and Protection at Munich has conducted long-term trials of fertilizers at its experimental plant at Puch since 1950. Fertilizers include: complete mineral fertilizers, fresh refuse, sewage sludge, and refuse-sludge compost. It has proved that refuse, particularly refuse-sludge compost, brings about considerable yield increases as compared to non-fertilized tracts. In four years, during which a complete mineral fertilizer was directly applied, this chemical fertilizer showed a clear superiority over refuse. Nitrogen-phosphorous-potash (NPK) fertilizer increased the yield by 57%; with refuse-sludge compost the increase was about 45%. The same rate of increase was obtained with activated sludge, while fresh refuse was clearly inferior in the years with direct application.

In the years without direct application, or after-effect years, the urban refuse and sludge demonstrated their notable after-effects. These wastes should therefore not be considered as fertilizers in the narrower meaning, but as soil builders. Their effect should not be measured only during the year of application but after the passage of a longer period of observation.

In trials conducted in parallel on tracts of very different kinds of soils, the 7-year experiments at Puch also showed that the refuse-sludge compost, consisting of 2 parts summer domestic refuse and 1 part of dried sludge (mixed and composted together) furnished an efficaceous product for soil improvement and a good fertilizer. These facts have so great a significance for supplying humus to agriculture and, above all, to horticulture that it cannot be fully grasped at present because the present sources of humus for horticulture in the vicinity of cities are becoming ever lesser with increasing motorization. Refuse-sludge compost, made in a form suitable for use by farmers and gardeners and sold at a reasonable price, can serve perfectly to fill the gap in the humus supply. Collaboration of urban and rural districts is required to solve all the many problems. Interested circles in Bavaria should now approach an agreement on the manufacture and use of refuse-sludge composts.

b. Straub, H. 1956 - The Sewage Treatment and Compost Plants of the City of Baden-Baden. Reprinted from: Das gas- und Wasserfach, 92 (24) Oldenbourg Publ., Munich, 10 pp.

Abs. The location of the spa of Baden-Baden and its requirements with respect to the sanitary removal of wastes poses problems for the city administration regarding sewage and refuse disposal. The town can no longer tolerate refuse dumps in its vicinity as these threaten to pollute water, breed rats and flies, and create other very serious nuisances. As the incineration of refuse in a city of 60,000 would be economically impractical, we have studied the process of composting refuse and sewage sludge together, as well as the required equipment and facilities. The city has started construction of a sewage treatment-composting plant, including clarification of sewage, sludge digestion with gas collection, and composting of screened refuse-sewage sludge. This plant will remove and convert the entire waste production from the city into useful substances---methane gas and compost.

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The author describes in detail the installation at Baden-Baden and supplements his report with diagrams and photos. By the Baden-Baden example, he shows how small and moderately sized towns can treat refuse and sewage rationally. Cost figures indicated for construction and operation of the sewage treatment plant are based on experience, but those for the composting plant are based on conservative estimates. However, the author cites the first figures for operation costs of the composting plant and proposed to complete them after the plant has been in operation for a longer time.

c. Straub, H. - Composting of Community Wastes-- A Report on Experiences at the Baden-Baden Plant. Reprint from: Gesundheits-Ingenieur, 77 (19/20), Oldenbourg Publ., Munich, 10 pp.

Abs. After some general remarks on the disposal of domestic wates, the author reviews methods of disposal, giving attention to the varying composition of such wastes. The figures on the yearly quantities and composition of wastes in Baden-Baden are very valuable for purposes of comparison (see: H. Straub - "The yearly distribution of domestic wastes." Staedte-hygiene, 4 (2) p. 49 1953). A detailed description of the procedure employed at Baden-Baden is given. The costs of construction and operation should be of interest to engineers. This paper should be considered a follow-up to the paper cited above.

d. Straub, H. - Making Compost from Sludge and Refuse. Berichte der Abwassertechn. Vereinigung e. V., Reprint from No. 1 (the Stuttgart meeting), 25 pp.

Abs. This paper contains the results of investigations the author performed at an experimental station in Baden-Baden for the composting of refuse-sludge mixtures, as proposed by Dr. Pöpel of the Polytechnical Institute of Stuttgart. On the basis of the results obtained, a composting plant was constructed at Baden-Baden. The paper contains not only theoretical problems relating to composting of wastes but also valuable data regarding the use of compost from wastes in practice. This paper constitutes pioneer work.

e. Stahlschmidt, V. 1956 - Development of the Dano (Biostabilizer) Method for Composting Refuse and Sludge. Reprint from: Städtehygiene, No. 12, Publ. Dr. W. Günther, Vienenburg am Harz, pp. 275-7.

Abs. The Dano Company at Copenhagen has built installations for the removal and treatment of refuse since 1930. The wastes were then mixed in a rotating silo and pulverized in an "Egseter" apparatus, then screened and composted in piles in the open. Such plants exist at La Chaux-de-Fonds, Switzerland and Küsnacht, Switzerland. The biological decomposition of refuse, however, required too much space, time, and labor. We therefore sought to accelerate the process and the Dano Company initiated laboratory research. The result of the studies was the Dano "Biostabilizer". In Switzerland there are Dano plants at Rüschlikon and Chur (Coire).

This paper discusses the methods and laboratory experiments, including conclusions for practical application.

f. Wurfbain, H. 1956: Experiences with Composting Plants Using the Rasping (Raspel) Method. Reprint from: Städtehygiene, No. 12, Publ. Dr. W. Günther, Vienenburg am Harz, pp. 273-5.

About 50,000 tons yearly of domestic refuse are treated at the Raspel plants in Holland at Vlissingen, Delft, Schiedam, Sneek, and Almelo. About 45,000 tons of pulverized refuse is obtained, yielding about 40,000 tons of compost. The cities of Arnheim and Hengelo have likewise decided to build Raspel plants.

The author gives a short description of the Raspel plant. The plant treats 97% of all refuse, the remainder being large combustible items which are incinerated. The worthless residual is about 10%, thus 87% of the total refuse is composted in piles in the open or distributed as raw material for hotbeds. The paper describes the various machines, gives average current consumption at the plant, and presents general operating costs.

g. Composting of Refuse and Sludge (4 reports). These reports originated at the meeting at Bad Kreuzbach, Apr. 20, 1956, under auspices of the Rheinland-Pfalz ministries of agriculture, viniculture, and forestry.

(1) Straub, H. - Evaluation of Refuse-Sludge Composting Plants in Community Management.

Abs. Refuse is increasing and the wastage in paper, glassware, packing materials, tin cans, and ashes is much greater than formerly. The problem of refuse haul has led large cities into emergency solutions. Attempts have been made at incineration and many large cities have had incinerators for decades. In Germany only two remain in service, at Hamburg. Other incinerators, some of which are modern, exist at Parks, Göteborg, Stockholm, Zurich, Bern, Basel, Lausanne, where conditions do not permit any other solution. Construction costs of incinerators has risen from 40 to 80 German marks per person. That means that, with 6% interest rates to be paid on the amortization, for a city of 100,000 people the interest on the capital per year will be 360,000 German marks, or 9 marks per cu. m. of raw wastes burned. Operating costs of incineration will run 9 to 12 German marks per ton of raw refuse, or 3 to 4 marks per cu. m. without interest on capital. This interest far exceeds the operating costs and is the reason why medium and small cities have long ago given up incineration.

Principles of the English process of "controlled tipping"(Ed. note: sanitary landfill) are then discussed. This method has also been used successfully in Arnhem (Holland) for reforestation of waste lands. This process, however, is limited to use in special cases. If no sites exist for dumping, no possibility exists for controlled tipping, and the financial means do not permit incineration, the only practical solution left is composting. Towns have been turning to composting of necessity.

The author believes that any community must concern itself with the urban health needs. If the compost produced finds use in agriculture, it is a logical consequence of the proposed solution, not the result of researches made with a view to finding substances for improving the soil. City officials should contact agricultural and forestry interests as the problem can only be solved by collaboration in furnishing a market for the compost. The communities need to bear the costs of waste disposal on their own, however, but an economical solution and a source of revenue should be kept in mind. Neither in a sewage treatment plant nor a refuse composting plant is to be expected that incoming and outgoing costs will be balanced.

The different processes of composting are next described with details on the Baden-Baden plant. In conclusion, the requirements formulated by the city officials should be:

1) Select a process enabling the year-round treatment of domestic wastes so that all open dumping is eliminated;
2) Select a process allowing recovery of useful matter in order to reduce operating costs;
3) Combine treatment of refuse and sludge as it is increasingly difficult to sell sludge in any other form;

4) Assure sale of compost through a comprehensive agreement with agricultural and forestry management;
5) Assure reasonable subsidies in order that the inconveniences and costs of removal of urban domestic wastes are compensated for by the advantages of an exemplary urban hygiene.

(2) Sauerlandt, H. - Refuse Compost to Reduce the Shortage of Humus

Abs. After some remarks on the scarcity of organic fertilizers in many agricultural fields, notably viniculture, the effects of organic fertilizers on plants and soils are given while a distinction is made between three types of manures:

1) The easily decomposable fertilizers (fresh or green manures) are active in decomposition in the soil but lead to diminution of soil organic matter following their complete decomposition.
2) Rotted manures, such as piled or buried stable manures, decompose more slowly than the green manures so, over the years, soil treated with this type of manure maintains its level of humus content.
3) Composts of stable manure, refuse and refuse-sewage sludge show the least loss of humus by decomposition and therefore increase the humus content of the soil.

The properties and analyses of various domestic waste composts are given and the effects of individual components described. The value of composts is in no way defined by its chemical content but is due to its merits as a means of improving the soil. Refuse composts are almost entirely made up of crumbly particles that are stable and resistant to the effects of climate, that are important in soil improvement (notably moisture-holding capacity), that diminish erosion, completely eliminating it after repeated applications. Conditions for friable soil structure are particularly good with refuse compost.

The basic elements involved in the formation of crumbly compost particles are the humic acids resulting from the microbiological decomposition of the organic substances and also from the small clay particles that are generally present in refuse in considerable quantities. Sufficient calcium or lime and carbonic acid are also needed for the formation of crumbly particles, the latter being formed from decomposition and serving to dissolve the calcium. Flocculating substances, such as those formed during the oxidation of substances containing sulphur and which combine with iron to form ferric sulphate, must be present to form friable particles. Clay and humic acids are flocculated by calcium and iron salts and these come in close contact with less decomposed organic substances. The result is that the finer particles cling to the coarser ones, forming aggregates of weather-resistant friable particles.

By means of this friable structure formed either in small animal or earthworm droppings or by the processes described above, the enrichment of the humus content of soils is obtained.

(3) Klenk, E. - Ten Years' Experience with Refuse Compost in Viniculture.

As the material in this lecture is identical to that in a previous article in this issue, it is not summarized here.

(4) Schmitz, F. - Refuse-Sludge Compost Evaluation by an Agricultural Authority.

Abs. As a representative of agricultural authorities, the author gives some points to be considered in construction of a plant for composting refuse and sludge. The requirements of the agriculturalist should be considered in preparation of wastes for agricultural uses. Composting should be conducted in such a way that the most precious substances -- organic substances -- are preserved as far as possible and that harmful or worthless constituents, such as glass fragments, small stones, etc., are eliminated. The sale price of the compost plays a considerable part, of course, including the transportation charges. City officials should be asked to cooperate in the distribution and price-fixing at least because the municipalities should consider the complete cost of the refuse disposal.

The speaker avoided the term "fertilizer" for refuse compost. The farmers have a very definite definition of fertilizer on the basis of nutrient substances and composition. From the point of view of agriculture, compost is a product for improvement of the soil. It is difficult today to obtain soil with sufficient humus for numerous agricultural projects, due to the severe decrease in cattle raising. Motorizing and mechanizing have further contributed to the disappearance of dray animals. In Germany the number of animal-drawn vehicles declined from 1.8 million in 1935-1937 to about 1.5 million in 1954, a loss of 300,000. The number of tractors increased during the same period from 20,000 to 371,000. In the Kreuznach region the number of cattle declined from over 32,000 head before the war to 26,000 in 1955. As agricultural projects must reckon with a far smaller supply of stable manure than formerly, the agricultural utilization of urban domestic wastes is arousing increased interest in the German republic.

7. Communications

The following reprints are available from the Secretary as long as the supply lasts:

Hahn, U. 1955 - The use of domestic waste in the management of Dutch forests (German).

Rossberg, H. 1956 - The new compost plant at Duisberg-Huckingen (German).

Steigerwald, E. and Springer, U. 1953 - Further experiments with refuse, refuse compost, and refuse-sludge compost, 1950-1952 (German).

Rohde, G. 1954-5 - Composting of refuse.

Allenspach, H. 1956 - Investigations on composting of sludge and refuse mixtures.

Braun, R. - The refuse problem in Switzerland.

There are still a few copies of Information Bulletin No. 1, of which 600 copies (total) printed in German and French were sent to interested persons in 22 European and other nations. The numerous comments received show us that our Information Bulletin is filling a real need. We ask the experts in various lands to help us develop our information service by sending us important papers on the results of research in relatively short articles. Longer articles will be accepted by the Swiss Review of Hydrology (Schweizerische Zeitschrift für Hydrologie, Editor: Dr. O. Jagg; Birkhäuser Publ., Basel).

At the time of the meeting of AkA, July 4-6, 1957, at Düsseldorf, the journal "Das Gas-und Wasserfach" published in a special issue all the speeches made at the symposium on present problems of removal, treatment, and utilization of domestic wastes in 1955 at the Federal Polytechnical Institute of Zurich. This special number is being sold by the Conference Bureau in Düsseldorf.

The International Congress of INTAPUC (International Association of Public Cleansing) will be held October 15-18, 1957 at Frankfurt on Main. The IRGR will be represented there by the President, Dr. O. Jaag, who will present a paper "Present problems of refuse composting."

INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)

Information Bulletin No. 3

October 1957

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International Research Group on Refuse Disposal (IRGR)

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1. Foreword by the Secretary

The Board of Directors of IRGR has revised the printing of the Information Bulletin. The first two numbers, of which 600 copies apiece were printed (400 in German and 200 in French) have been rapidly exhausted. The Secretary receives requests almost daily for the bulletin so that we have been obliged to reprint the first two numbers. Subsequent numbers, of which the printings will be 1,500 copies (1,000 in German and 500 in French) will be printed in a more rational (sic) manner.

Bulletin No. 3 concerns the working session of Aka primarily. How urgent the problems of satisfactory removal and disposal of urban domestic wastes have become recently was shown in a very impressive way at the Düsseldorf meeting where 220 experts from 14 European and other nations were present. General organization was in the hands of Dr. Straub, Secretary-General of AkA, while Dr. Jaag, President of IRGR, was occupied with directing the session.

Participants learned of composting research in Germany, the Netherlands, Belgium, France, and Switzerland. The problems, methods of evaluation, and use of refuse compost in various agrarian enterprises were stressed. Initially the main addresses and supplemental reports were sent to each participant. This illustrated brochure was printed by Mr. Plichta in Düsseldorf and was favorably received. A few copies are still available at the office of Secretary-General of AkA (Chief Government Works Inspector Dr. Straub, City of Baden-Baden) or at the home office of IRGR. The address by Mr. de Groote, not printed in the brochure, is presented in this bulletin. We hope to publish later the address of Dr. Keilling of Paris.

Participants visited the modern compost plant of the village of Duisberg-Huckingen. This plant composts refuse-digested sludge in a Dano biostabilizer. The reforestation of Zonser Heath, near Düsseldorf was also visited. Results obtained by Mr. Cosack in the use of compost for reforestation were remarkable.

2. The Meeting of der Arbeitsgemeinschaft für kommunale Abfallwirtschaft (AkA), July 4-6, 1957 with Participation by IRGR by W. Herrmann of Krefeld.

The working session of AkA, held at Düsseldorf with collaboration of IRGR, treated the question-complex of disposal of the waste products of our civilization--liquid and solid. The general concern about sanitation, especially the management of waters, and the concern

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about how the soil might be again built up caused a splendid number of experts, among them 70 from foreign nations, to exchange their experiences and problems in the field of treatment of community wastes.

The possibility exists of satisfactorily disposing of the solid community refuse by incineration; but this sets aside the requirement of returning to the land what people take out of it in gardening and farming. This requisite was of primary importance during the meeting. The problem has many aspects, such as: the nature of the waste concerned, the amount and composition of the refuse, its transport, methods of preparing it, its price and quality, treatment of concomitant residues, distribution of treated wastes, and relation to consumer requirements.

Mr. Pöpel of Polytechnical College of Stuttgart made clear the importance of research and investigations concerning the design, construction, and evaluation of composting plants. Mr. Springer of the Bavarian Provincial Institute for Plant Culture and Plant Protection, Munich, discussed the chemical, physical, and biological tests that make possible uniform evaluation of a refuse or sludge treatment process and enables the entire course of treatment to be controlled. M. Teensma, N. V. Vuilafvoer Maatschappij (V.A.M.), Amsterdam, spoke on recent experiences with use of refuse compost in Holland.

Messrs. Sauerlandt and Banse of the Institute for the Management of Humus, Braunschweig-Völkenrode (Brunswick), Germany, discussed refuse compost and its action on plants and soil. Mr. Cosack, Regional Division of Forestry, Düsseldorf, outlined the reforestation experiments at Zonser Heath before the visit was made. Mr. Rossberg, Duisberg, did similarly before the visit to the sewage treatment-compost works of Duisberg.

The Düsseldorf meeting presented the problems and the results at present and indicated that there are thorough, definitive studies being made of the over-all problem. There exist simple directions permitting the following of composting in all stages and of all types of wastes--refuse, digested sludge, slaughterhouse wastes, or street sweepings.

A few points are not completely cleared up. Results in one country are not applicable without further ado elsewhere because raw materials, soils, and climates differ. These differences may be thought to be a barrier to international collaboration but, precisely that kind of exchange of ideas and experiences that each country can contribute, stimulates later research in the various nations. France ships large quantities of compost to Mediterranean areas for soil improvement, while Berlin has for 30 years delivered compost by barge to this same needy area. If we consider that in Northern Westphalia 9,000 hectares of land are lost to profitable industry yearly but that worn-out lands are still available which urgently require soil improvement, it is evident that the various composting processes deserve to be thoroughly studied.

Except in special cases, it appears that the use of compost made from urban wastes has still not found efficacious application in agriculture. The question of transportation of compost in the extent to which its production processes may be perfected will be the particular object of future studies. Differences between fertilizers and soil builders were discussed and it is well that the voices of agriculture, horticulture, and viniculture have spoken decisive words. The composition of wastes is gradually changing and the volume of industrial wastes rapidly increasing.

The session led to the delineation of three important tasks for future solution:

1) The collection and treatment of community waste products is to be worked out further from an economic point of view.
2) Determination of the methods for simple and uniform evaluation of the end-product of the waste treatment plants and enable the control of the composting process.
3) Establishment of uniform research conditions for agricultural evaluation of treated wastes and the determination of their action on the individual species of plants.

The meeting has revealed the need for management of urban domestic wastes and has demonstrated that feasible and proper solutions of this vital problem have become of paramount importance for human society.

3. Analysis and Evaluation of the Quality of Refuse Compost by Engineer R. de Groote, State Research Station for Horticulture, Gent, Belgium (Supplementary report to the 2nd main theme presented at the AkA meeting).

Introduction:- The quality of refuse compost certainly plays a large role in its evaluation by consumers. Compost is a complex fertilizer with chemical, physical, and biological processes occurring which contribute to the harmonious development of the plants while maintaining the soil in a state of fertility or making fertilization. feasible. The various characteristics differ from city to city and from season to season. As the various composting processes are responsible for the degree of maturity of these products, it is necessary that both producer and consumer analyze compost regularly to determine its actual value. The composting plant operator should take daily samples of the material at the beginning, at intervals during the process, during maturation (or curing), and after its self-pasteurization. In this way important scientific data on quality and characteristics of compost are assembled. These data not only inform consumers but make possible regulation of the transformation process so that it approaches ever closer to the ideal quality. Such analyses might also test for substances injurious to vegetation, of paramount importance when compost is used in horticulture or market gardening. Objective competent interpretation of the results of analyses is of greatest importance.

Analysis and evaluation of refuse composts may be summarized into: 1) sampling, 2) chemical analyses, 3) physical analyses, 4) microbiological analyses, 5) phytophysiological tests, 6) interpretation of the results.

1. Sampling:- The manner of sampling is the basis for successful scientific analyses of refuse compost. Sampling of compost is the same as that for soils in horticulture: from different parts of the compost pile at a depth of about 50-70 cm. equal amounts of compost are taken (a few Kg). As the compost is not stable certain chemical analyses should be commenced as soon as possible. Store the samples in a refrigerator if this immediate analysis is not possible.

2. Chemical Analysis:- Exact methods of analysis exist for all nutritive substances and for certain trace elements that are indispensable for plant growth. Routine quantitative methods of analysis, however, offer certain inconveniences for a composting plant, such as difficult organization for the laboratory and the loss of time. The very precise results which they obtain are dispensable for the practical control and evaluation of the compost.

The improved colorimetric and turbimetric analyses developed by Prof. E. Truog, University of Wisconsin, College of Agriculture, for quantitative and qualitative analyses of soils are very well applicable as to rapidity and precision, to the serial analyses of refuse compost. The larger number of tests per sample allows a good diagnosis of the compost in question, especially with regard to nutritive elements, hydrogen ion concentration (pH), and chloride content. A skillful laboratory worker can perform 9 quantitative determinations in 15 minutes (pH, phosphorus, potassium, calcium, magnesium, nitrate, ammonium, sulphate, and chloride).

A list of reagents used in these various colorimetric techniques follows:

Determination	Reagent
1. pH	Universal indicator
2. Phosphorus	Molybdate soln., stannic chloride
3. Potassium	Alcoholic soln. of sodium acetate, cobalt and sodium nitrites.

4. Calcium	Sodium oxalate soln.
5. Magnesium	Yellow titanium soln., sodium hydroxide soln.
6. Nitrate	Brucine soln., mixture of sulfuric and phosphoric acids.
7. Ammonium	Nessler's reagent.
8. Sulfate	Barium acetate soln.
9. Chloride	Silver nitrate soln.

Truog's colorimetric method is based upon a weak concentration of hydrochloric acid for extraction of the compost by which the directly assimilable nutritive substances are determined. The serial colorimetric analysis of compost enables us to follow the slow decomposition of the compost.

For other elements such as iron, very good colorimetric analyses have been formulated (for iron: thiocyanate, potassium permanganate, and hydrochloric acid). Also for manganese there is a good colorimetric method employing sodium para-periodate. All of these determinations were carried out with appropriate photometric apparatus, using standardized colorimetric and turbimetric scales. The apparatus is manufactured by several specialized companies of world-wide reputation.

Particular attention should be given to the determination of pH, because pH plays an important, even a decisive, role in agriculture and particularly in horticulture. As compost pH varies generally from 7 to 8.5 and as horticultural soils should have pH values of 5.5 to 6.3, the exact determination of the pH value permits calculation of the amount of compost to be incorporated into soils and culture substrates. The potentiometric method of determining pH is therefore advisable.

Moisture content of compost is equally important. A good measurement of moisture content of composts makes use of the reaction between water and calcium carbide ($Ca\ C_2$) and the measurement of the released acetylene. The reaction is conducted in a small steel container (bomb) and the acetylene creates pressure as it accumulates. The pressure, related to the amount of moisture in the compost, is easily read off a manometer. The method is very rapid and simple.

Measurement of carbon dioxide (CO_2) production in compost is useful in certain cases, such as the use of compost in hotbeds. The determination of humus in the compost has been developed by Dr. U. Springer in his report entitled "Analysis and Evaluation of Refuse Composts" (see IRGR Bulletin No. 1).

3. Physical analyses:- Physical properties should not be neglected in the evaluation of refuse composts. The following physical data contributed to a better understanding of the compost and facilitate its use:

a. Density or specific gravity.
b. Temperature during composting, curing, and, in certain instances, use of compost (as in hotbeds). There is a whole series of special thermometers which are very practical for measuring temperature of the compost pile. Placing recorder sensing elements at various depths gives continuous information on the variations in internal temperatures of the pile.
c. Particle size of the compost may be simply determined by a conventional set of sieves. Special attention should be given to the amount and size of glass fragments, particularly in the use of compost for horticulture. (Glass splinters over 3 mm. long should not be present.)
d. Moisture content may be determined electrically, based on measurement of conductivity (Bouyoucos' measuring bridge). Rod hygrometers also indicate the relative percentage of humidity in the compost.

4. Microbiological analyses:- Although the collection of samples and methods of analyses are very complex, it is suggested that the plant personnel examine the bacteriological quality of the compost. The quantitative determination of thermophilic bacteria, which are very important in the decomposition of organic matter, and the determination of pathogenic microorganisms give valuable indications in evaluation of the compost. Temperatures of compost assist in interpretation of the results of microbiological analyses.

5. Phytophysiological analyses:- The importance of chemical, physical, and microbiological data in evaluating compost is indisputable but the optimum development of the crop is the decisive factor, the same as with any fertilizer. It is hardly possible to predict the total effect of a fertilizer on crops. Agricultural evaluation of a fertilizer can be made by comparing the harvests of treated fields with untreated fields and also by means of systematic observations. Differences in nutritional requirements of individual species and varieties of plants pose a great problem in the use of composts. The Research Station for the Improvement of Ornamental Plants at Gent has assembled valuable data over the last four years on the use of compost for optimum growth of various ornamental plants. Results on about 150 species and varieties will soon be published in the "Review de l'Agriculture" of the (Belgian) Ministry of Agriculture.

Observations of the plants up to their full growth gives needed data for absolute compost evaluation. Although this method is good for scientific investigations, it is not suitable for the composting works or for the consumer. It is therefore better to conduct phytophysiological tests on the compost to give results on the reactions of plants, particularly cuttings. The following tests are easy to conduct:

a) Toxicity tests:- As the quality of wastes is not subject to testing or control regarding possible substances injurious to plants and as these substances may cause plant damage in very low concentrations, tests are needed of the toxicity or non-toxicity of compost. The following test is recommended:

To 200 g. of dried compost add 0.5 liter of distilled water and 0.5 liter of aqueous solution of citric acid. After maceration for one hour, filter and add increasing amounts of filtrate to a certain number of aquiculture vessels containing a complete nutrient solution. Each vessel contains a rooted cutting of a trial plant, preferably a series of 10 cuttings with a control. Rooted cuttings of impatiens, coleus, lathyrus, begonia multiflora, and lettuce serve very well for these tests. After 1 to 3 days of observation and comparison with the control, it is easy to prove the toxicity or non-toxicity of the compost. Observe the root system as some toxic substances cause the roots to curl up in a characteristic manner.

Germination of seeds on filter paper moistened with compost filtrate also gives a few indications quickly. In both tests the temperature of the environment is very important. Dr. Springer has observed that the resistance capacity of plants, especially vegetables, against toxic substances and trace elements varies considerably between species and further scientific data are needed in this field.

b) Nutritional test:- An easy test is to plant a number of trial cuttings in small pots containing a mixture of compost and standardized soil (50%). In 2 to 3 weeks the nutritive value of the compost can be determined in comparison with simultaneously-planted control plants. To determine the influence of a particular nutritive element, Dr. Springer recommends the method of E. Mitscherlich involving cultivation in trial pots. The neubauer and Aspergillus methods mentioned by Dr. Springer are also useful.

c) Test for weeds:- The high temperatures reached during composting should destroy all weed seeds and pathogens. It is simple to determine the presence of viable seeds (mostly weed seeds) in compost by mixing compost and sterilized soil in equal parts, putting a potful in a hothouse or incubator (23-30°C). Within a few days the sample will give very conclusive results regarding possible germination.

It should be noted that certain pathogen tests, particularly for nematodes, are of extreme importance for horticulture and market gardening.

6. Interpretation of Analytical Results:- This is not an easy task. Although a few analyses are of special interest, it is the overall results that are decisive. A thorough knowledge of plant nutrition and of all problems related to the culture substrate is necessary in order to determine the true value of refuse compost.

4. The Reforestation Experiment at Zonser Heath by J. Cosack, Chief Forester, Regional Forestry Division, Düsseldorf.

I must repeatedly refer to the Netherlands with regard to the use of raw urban wastes or composts because of their striking and astonishing results. Impressions gained there in 1952 led to similar experiments here in Germany. The Holland experiments show that the use of refuse compost on poor, devastated soils is decisive for their reclamation and that artificial fertilizers can yield outstanding results only if humus substances are present in sufficient amounts. Domestic waste compost has a considerable influence on state of decomposition, water retention and buffering capacity, and the formation of nutritive substances which increase biological activity. Compost definitely increases soil bacterial life. Heat released from decomposition of organic matter influences plant growth. Also the physical improvement of poor soils may be demonstrated best by the increase in moisture-holding capacity.

Dr. Eidmann of this Institute has studied the biological activity of soils treated with compost and has found increases following its addition. These findings will be explained during the excursion.

An area one kilometer west of the City of Zons was obtained for these experiments. It is characterized by large, shifting sand dunes which are windblown formations of the alluvium consisting largely of sand and gravel from the lower banks of the Rhine valley. The groundwater level is at a depth of 6 to 9 meters. The dunes have been fallow for a long time. In places there are clumps of pine, oak, redoak, and locust (acacia) of little value. The barren land has largely become wasteland or heath except for individually plowed areas used during the last war for the raising of potatoes or oats. Ground flora consists of grasses which show the poor quality of the soil, heather, and isolatedly of broom (Genista).

The experiment in improvement of these fallow soils through the addition of screened compost from an old heap was begun in 1953-1954. Amounts of compost ranging from 0 (control) to 75 tons per hectare were made. (Ed. note: a hectare is 2.47 acres.) Compost was harvested and screened by means of a vibrating conveyor and screen similar to a potato-sorting machine. Compost was applied to the surface of the soil, partly before and partly after preparation of the soil with a stripping plow. During 1953-1954, a total of 13 test areas was treated with varying amounts of compost. The areas were planted with various lumber trees such as Douglas fir, Scotch pine, spruce, and also Japanese and European larches, beech, and cherry.

During 1956 additional trial plots were treated with compost from Düsseldorf-Ham or with domestic waste compost from the Baden-Baden plant. For comparison, plots were treated with chemical fertilizer.

February-May, 1954 were exceptionally dry and windy so that during early May the plantings on areas with less compost began to dry up. Only the heavy rain of May 30 gave hope that the plantings on the heavier treated tracts would survive. Soils with low treatment remained dry because of their low water-holding capacity and the rain of May 30 ran off superficially. These observations show the importance of the water absorption associated with refuse compost.

The spring of 1956 was a wet one so there was no chance of comparing the new plantings with the 1954 plantings. It was established definitely in 1954 that large dosages of compost decreased the loss of plants through drying. The loss on areas of heath treated with 30 tons or less per hectare amounted to up to 90%, while in plots treated with 45 tons the loss decreased to about 30%, at 60 tons to 5-10%, and at 75 tons to less than 5%. This is probably due to the organic substances contained in the compost absorbing and retaining moisture better than the soil. The ground flora changed after use of compost; thus, on plots treated since 1954, great mullein, elder, willow herb, and a species of dock have appeared, glyceria is spreading, and the existing silver grass is receding.

The height of pines on treated plots has been regularly observed since 1954 and is given below for three application rates:

Tons/hectare	Height of Pines (cm.)		
	1954	1955	1956
45	8.6	18.8	49.1
60	9.6	28.3	58.2
75	10.6	33.5	75.0

In the spring of 1957, measurements were taken before the beginning of spring growth by the over-all height method. The tallest plants on a continuous flat surface plot of 2 meters were measured, 300 plants were measured on each plot:

Tons/hectare	Height(cm.)		Diameter(mm.)	
	Range	Average	Range	Average
45	25-74	43.7	6-20	11.1
60	30-88	57.1	7-20	12.5
75	41-97	70.5	7-23	14.9

We reached similar conclusions with this method. All other 1954 trial plots showed results of growth that were in line with the above observations.

Dr. Wittich determined the content of nutrient materials and the dry weight of pines above the surface on plants of average size this year. A considerable increase in both occurred in accordance with increased applications of compost. Investigations are continuing to determine the limiting amount of compost beyond which further addition is purposeless.

The two composts tested are:

Compost I - sifted from a pile of waste that was several years old.

Compost II - composted summer refuse mixed with 15% fresh fecal matter, allowed to rot for 6 months.

With Compost I the nitrogen intake of spruce seedlings was considerably increased, during the second year even greater than the first. Intake of phosphoric acid rose still higher percentagewise, that of calcium a little less.

With Compost II similar results were observed in the case of small and medium applications, but a considerably lesser assimilation of phosphoric acid resulted when maximum compost application was used. This is due to retardation of the chemical reactions.

The action of compost treatment with spruce seedlings was very noticeable and no toxic action was perceptible. The trials with compost on spruces generally showed very strong fertilizing action regarding calcium and considerable action regarding N, P, and K. To obtain maximum growth it is necessary to practice prudent dosages and, under certain conditions, an artificial correction of pH.

Some experiments were made in which the two composts were treated with ammonia gas but, in all except the weakest dosage (which more than doubled the nitrogen intake), damage from too high a concentration appeared and caused death of many plants.

We may envisage a more general employment of domestic waste composts, above all else for reforestation of poor and devastated lands. Beyond that, perhaps, the use of domestic waste compost for horticulture and viniculture, as for agriculture, is taking on an even greater significance.

5. Summary of Discussions at the meeting of AkA in Düsseldorf

The following summaries are classed according to subjects. All individual discussions cannot be published.

a. Composting and Methods of Investigation.

Dr. Rohde (Berlin) discussed "natural surface composting", a method he developed. He outlined four stages of decomposition: first, the formation of molds; next, actinomycetes; then, basidiomycetes; and finally, aerobic bacteria. The same stages occur for domestic wastes, stable manure, sludge, pig manure and street sweepings. The phases are not sharply defined. Dr. Rohde calls the fungi state "Futterverpilzung" and considers it most important because the molds take up many vitamins and hormones and fix ammonia. They will produce flavorful fodder and hundreds of thousands of pigs are now fed with such "fungus-fodders".

Dr. Springer (München) commented on the paper by Dr. Sauerlandt. Dr. Sauerlandt was among the first to consider the physiological value of nutrient substances, particularly of nitrogen, in refuse compost. He showed how the active nitrogen may be estimated with the Aspergillus test and how in vitro trials enable determination of soluble nitrogen. Sauerlandt concludes that field research on the evaluation of compost requires 6 to 10 years for satisfactory conclusions. Small scale research showed that increasing oxygen in compost also increased accumulation of nitrogen and humic acids. The accumulation of nitrogen may be a measure for the degree of maturation of a compost. The hypothesis of formation of humic acids seems to be confirmed but there is question if their formation is always preceded by an oxidative decomposition of the lignin. There are different results between aerobic and anaerobic decomposition; anaerobic action yields more humic substances although the stability thereof is less.

Dr. Kick (Bonn) stated from the viewpoint of plant nutrition it is of little significance whether the compost is produced by aerobic or anaerobic decomposition. Aerobic decomposition, however, is desirable because the high temperature kills weed seeds, worm eggs, and pathogens.

Dr. Springer, commenting on the talk by Dr. Braun (Zurich), said it is difficult to define the concept of maturation of a compost. Amount of CO_2 production or appearance of nitrates may measure the end-point. Manure composts are considered stable with C/N of under 20, a degree of decomposition of 30-35% (amount of the organic substance soluble in acetylbromide), and a ratio: nutritive humus/permanent humus of 2. Well-decomposed compost shows a C/N of 10 to 15 and degree of decomposition of 40%. Still more mature humus exists in brown and black earths, consisting of about 80% permanent humus and the remainder chiefly uronic acid complexes which are biologically resistant. Soil conditions will determine whether a compost or stable manure of greater or lesser maturity should be used. Sandy soils poor in humus require a product rich in permanent humus, heavy soils require more nutrient humus.

Dr. Gerretson (Netherlands) commented on the remarks by Dr. Springer. He objected to determining organic matter (volatile solids) by combusting at 500° C. or even 1000° C. as he reasons that coal and coke are not to be classed as organic substances. Thus, if the organic matter is stated as 25% and half of it is coal or coke, one would be led to believe he had a better quality of compost than he actually had. He suggested the designation "loss by burning", instead of "organic substances". (Ed. note: in the U. S. we use the term "volatile solids".) Springer also suggests using C/N contained in the active organic substances; Gerretson suggests using active C/active N for the ratio. Not more than 10 to 20% of the total nitrogen is assimilable by plants or microorganisms, the bulk being so firmly bound (chemically) that it is completely without biological significance. Gerretson determines the nitrogen hydrolizable with sulfuric acid as well as total nitrogen.

b. Composting of Digested Sludge.

Dr. Rohde has composted considerable amounts of partially dried sludge alone from the Berlin sewage treatment plant (70% moisture). The material was turned many times until the moisture dropped to 60% and then composted it in piles into which aeration tunnels were dug. However, sludge is mostly composted with refuse (papers by Pöpel, Straub, Allenspach, and Braun). To compost all sludge and refuse from any one region requires drying the sludge to about 70-75% moisture. Dr. Braun reported better results using sludge concentrated in a vibrating thickener rather than on open sludge drying beds and believes this due to physical changes in structure due to the vibrator. Dr. Pöpel thought it was due to the water bound by the cells in sludge from drying beds. Results of research by the town of Gladsakse were similar to those by Braun and Allenspach in Switzerland.

Dr. Kick (Bonn) mentioned good results with sludge-refuse mixtures at Baden-Baden, attributing them to good mixing of the wastes. The raw refuse contains more potassium while the sludge, of course, contains more nitrogen and phosphorus. Poorer results were achieved with plain refuse composting.

c. Elimination of Ashes and Glass

Engineer Dix (Saarbrücken) queried about elimination of ashes and removal of a percentage of glass from the compost. Drs. Pöpel and Kick said ashes should be removed before composting to insure a more homogenous product. E. Dryander (Halle) also stated elimination of ashes is indispensable in order to keep the proportion of inorganics in compost as low as possible. Without sieving to remove ashes, their proportion in winter can hardly be kept below 66%. Dr. Rohde pointed out that under certain circumstances ashes are even desirable. He stated he had improved soil badly leached by sewage with fine ashes in the Berlin area. Similar experiments have been done around Paris.

Dr. Pöpel indicated that compost to be used for horticulture should be free from glass fragments. In forestry, they are hardly injurious up to a certain amount. Dr. Rohde uses compost on wastelands in Berlin where the lowermost layers contain dirt and glass and the upper layers do not. E. Dryander said that the removal of glass is part of the over-all composting problem and that combined air and density separation of hard components holds considerable promises. The Secretary (IRGR) indicated that this process of separation has been made practical at the Dano plant in Copenhagen. The new Dano plant at Chur, Switzerland has a similar installation depending on the basis of ballistic separation for hard materials. The procedure developed in the Bühler Machine Works at Uzwil uses hammermills to pulverize the glass and pottery. The compost made in the Netherlands according to the Raspel (Schiedam) process completely answers the requirements for freedom from glass slivers. (Ed. note: presumably in the last two methods, the glass is ground to sand and is therefore not objectionable. The Dano biostabilizer grinds somewhat but does not reduce glass to sand size).

d. Utilization of Fecal Matter

Schmidt (Nürnberg) asserted that sale of feces in the drying pits is difficult. Dry pit toilets amount to 20% in Nürnberg. Farmers who formerly were eager to obtain this fecal matter seldom take it today. Large pits at dump sites are therefore required for its disposal. Dr. Pöpel proposed allowing the matter to decompose in open ditches then dry it on normal drying beds.

Dr. Rohde composts pig manure from the numerous fattening stations around Berlin as farmers and gardeners refuse to use the odorous manure. He mixes the feces with industrial ashes, composting the mixture in open piles provided with horizontal and vertical aeration channels. When ashes are unobtainable, Dr. Rohde layers the manure 30 to 40 cm. high and 4 meters wide on natural soil, plowing up the material after 7 days to reduce moisture and promote aeration. Three more plowings at 7-day intervals are conducted, after which the material is heaped and composted normally. The piled material reaches temperatures of 60° C. in 2-3 days and the resulting compost is of good quality.

e. Destruction of Pathogens During Composting

Dr. Rohde illustrated his remarks on pathogenic microorganism destruction by showing pictures of round worms (Ascaridae) infesting slaughterhouse wastes from the Berlin central abattoir. After 4 days' decomposition no more active roundworm eggs could be detected. Eggs are destroyed in 10 days at 40° C. and in one day at 60° C. Dr. Rohde, with Dr. Oesterle, Berlin Medical Faculty, inoculated compost heaps with 17 different species of non-sporogenic pathogens and found that all were killed after many days of composting at temperatures between 50 and 60° C. Dr. Pöpel (Stuttgart) stated, on the basis of the literature, that most pathogens lose their virulence at about 50° C.; ascaris eggs, reknown as dangerous, have been killed in a short time when heated to 50° C.

f. Troublesome Odors

On a question raised by Engineer Dix (Saarbrücken), Dr. Rohde stated that odors during composting do not become troublesome if the process is properly conducted. Odoriferous putrefaction occurs when the material is too wet, changing the process from aerobic to anaerobic. Odors disappear as soon as 60° C. is attained. Flies and rats are not attracted to compost heaps.

g. Briquetting Refuse and Compost

Discussions of addresses by Engineer Allenspach and Dr. Braun indicated that the technique of transforming refuse into heating briquettes has been so well-developed in recent years that there are no longer problems. Such briquettes should have heating values near that of lignite (peat). Only the future can show whether the product will sell. Dr. Pöpel remarked that the briquetting suggested by Mr. Pfeil had already been achieved by Mrs. Harrar of France. More investigation is needed to find out if supplementary heat is needed to burn the briquettes. Temperatures of 800-900° C. or more must be obtained to avoid disagreeable odors but this subject is to be re-examined.

Dr. Pöpel answered the question of Engineer Dix as to the behavior of briquettes of partially decomposed substances saying that well-made briquettes permit rapid drying through capillary action which kills off microorganisms or causes them to form spores. The latter can be revived when the briquettes are broken up and moistened, especially if moistened with water containing nutrients. Run-off water from composting pits provides swift revivification. Spores in briquettes made by Harrar of France remain viable for a long time. Dr. Rohde does not recommend compression briquetting of compost because, under high compression, the compost may undergo anaerobic decomposition with destruction of protein and formation of hydrogen sulfide.

h. Industrial Wastes

Schmidt (Nürnberg) asked how to dispose of industrial wastes, indicating that difficulties arise with use of open fields and use of pits for acid wastes made surrounding lands unfit for farming. Engineer Allenspach (Switzerland) explained his method for disposal of oil residues: residual oil after extraction of mineral oil is led over coals and directly converted to gas. Fatty, sludge-like residues cause difficulty and they are discharged to a sand-bedded tank through which steam is blown to partly destroy the oil films and form new oils which are then drawn off and gasified as before. A further possibility for oily residues is incineration such as practiced at Zurich and Berne. Dr. Pöpel indicated that the higher oils may be regenerated but the process is not perfect in that incombustible, unusable residues are formed. However, there are a few firms attempting to develop a process without this disadvantage.

i. Improvement of Wastelands with Compost

Dr. Lamm (Eschweiler, Germany) mentioned the pitted land after removal of lignite (peat) in the Köln (Cologne) and Aachen (Aix-la-Chapelle) vicinities in which reforestation with poplars and acacias was tried. This land was admirably suited for reconditioning with the use of compost. Public officials and industry representatives have a duty to perform in eliminating these wastelands. Dr. Kick (Bonn) said trials have been made on reconditioning of soils lost through lignite strip mining which indicate great promise. Similar experiments in the Berlin area were described by Dr. Rohde.

j. The Use of Refuse Compost in Agriculture

Many participants endeavored to answer the question of Dr. Lamm (Eschweiler) as to why farmers today are still resistant to the use of refuse compost, including Dr. Jaag, Chief Government Advisor Schmitz, and Dr. Kick. Dr. Kick maintained that a suitable agricultural compost can be obtained only if preliminary sorting of raw wastes is practiced; the ashes especially should be removed. Reason is the diversity of requirements for different crops and soils. The same success is not always obtained with different crops and sometimes damage to crops is unavoidable. Thus, refuse composts cannot be as generally used as commercial fertilizers, stable manures, and dirt or turf composts used in farming and gardening. Dr. Kick reported on trials undertaken by the Agriculture Chemistry Institute, Bonn University, limited to use of refuse compost in truck gardening and horticulture. Compost use in raising cereals does not seem to be of prime necessity. Dr. Kick spoke of the good effect from the use of sludge-refuse composts made at Baden-Baden but declared that such compost is still much too expensive.

k. Can Refuse Compost be Considered a Fertilizer?

Mr. Schmitz discussed the question of domestic waste compost--fertilizer or soil builder? In many German composting plants the question of definition assumes great importance. Compost, in Schmitz' opinion, cannot be considered a true fertilizer and cannot be compared with commercial fertilizers. Talks by Messrs. Teensma, Springer, and Sauerlandt tend to class compost among the fertilizers. In Germany two problems occur: 1) Legal -- fertilizer manufacturers must have a permit and guarantee the various nutrient contents according to the official prescription of the fertilizer; 2) Usage -- the manufacturer must state the amount in kilograms of nutrients for crops and the directions for applying in quintals (hundredweights) (Ed. note: presumably the common hundredweight which is 112 pounds). The application rates given by Messrs. Springer, Teensma, and Sauerlandt all differ. Dr. Springer said that 100 tons of compost per hectare adds about 70 kg. of N per hectare to the soil. The effect of 100 tons of compost is therefore equivalent to only 3.5 hundredweights (cwt.) of calcium nitrate. Dr. Sauerlandt obtained yield increases of sugar beets of 50 cwt. by the use of mineral fertilizer with the addition of 100 tons of refuse compost. Estimating the cost of refuse compost at 100 German marks, we conclude that 1000 German marks of compost increases the yield a value of 300 German marks.

Mr. Teensma mentioned using 20 tons of compost per hectare to control heart rot and dry rot in the Netherlands. The same results can be obtained with 20 kg. of borax. But it should not be deduced from these figures that compost is of little value. Reluctance of farmers to use it, however, is based on just this kind of incorrect reasoning. Refuse compost should therefore be evaluated not as a fertilizer but as a means of soil improvement. It should further be noted that the Netherlands uses much more mineral fertilizer than the Federal Republic of Germany (80 kg. of N/hectare vs. 35). Holland therefore uses not only more compost but more chemical fertilizer.

Where there is a labor shortage, the use of a product like compost, which requires handling large quantities, has not gone very far. Compost use lies primarily in the fields of soil improvement and horticulture. We need analytical methods to determine needed accurate information on the true value of compost and on its possible toxic components, as well as the field and laboratory trials previously mentioned.

Dr. Straub (Baden-Baden) confirmed the fact that present law gives no possibility of designating composts as fertilizers, and we must therefore adhere to the term "means of soil improvement." The content of essential nutrients in compost is intrinsically low and naturally a mineral fertilizer is more economical on that basis. The value of composts is definitely not in the field of essential nutrients but in the physical-biological improvement of the soil.

6. Communications:

a. Formation of a Study Group of IRGR in France

Mr. George Dobrouchkess, Directeur du Bureau de Propagande et Documentation pour e'utilisation des ordures, 1 rue Huysmans, Paris, has very kindly directed the organization of a new study group in France and other French-speaking countries. Mr. Dobrouchkess, a Knight of the Legion of Honor, is a member of the "Humus" Committee presided over by Dr. Keilling. Information Bulletins in the French language will be distributed directly from Paris, except that the Zurich office will continue sending them to French Switzerland.

b. Further Papers from the AkA Meeting

In case the participants in the Düsseldorf session wish to publish their other papers or discussions elsewhere, we would like them to send us an abbreviated report which we can publish in the next Information Bulletin.

c. Reprints

The following reprints are available at the Secretariat:

Arbeitsgemeinschaft für Kommunale Abfallwirtschaft (AkA). Session brochure containing the papers read at the Düsseldorf meeting, 100 pp. with numerous illustrations and tables, price 12 Swiss francs. The brochure may also be obtained from: Herrn Oberbaurat Dr. Straub, Generalsekretariat der AkA, Stadtbauamt, Baden-Baden, Germany.

(Ed. note: The first 15 articles listed here are omitted in the interest of space because 6 were listed reprints in Bulletin 2 and 9 were summarized therein.)

Caspari, F. 1956 - Cities make prosperity.

Caspari, F. and Horstmann, O. 1956 - Natural soil conditioning through refuse compost.

Buck, K. 1956 - Fresh and composted refuse for soil improvement and fertilization.

Rohde, G. 1956 - Composting pig manure.

International Research Group on Refuse Disposal -- Information Bulletins 1 and 2 in German and French.

Some of these papers will be summarized in the next Information Bulletin.

INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)

Information Bulletin No. 4

March 1958

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1. A New Swiss Refuse Disposal Procedure by H. Hurter, Municipal Magistrate, Uzwil, Switzerland.

After many years of searching for a suitable mechanical method for preparation of refuse, the Bühler Brothers Company, a machine factory in Uzwil, has built a refuse composting plant in Lower Uzwil and has obtained about a year's results in practical operation that are most promising. This plant is briefly described and the results reported.

a. Buildings and location:- The plant building is of simple construction having a volume of 910 cu m and containing the following: a raw refuse storage bin with discharge platform on the upper level; conveying, sorting, and grinding area, transformer station, and rest room on the lower level. The machinery occupies room space of only 600 cu m. The area made available by the city of Henau for the sewage treatment plant comprises 18,000 sq m and is located on the Wil-Gossau highway. The buildings, driveways, and turning places of the refuse treatment plant require 3,100 sq m, while 1,400 sq m are required for actual composting.

Hauling distances for collecting vehicles from the centers of the villages served to date are: 0.9 km for Lower Uzwil, 2.1 km for Uzwil, and 3.3 km for Upper Uzwil. Selection of the central Uze sewage treatment plant as site for the refuse plant was made at the beginning because of the desire to compost sewage sludge with the refuse. A hillock of land about 10 m high was used as a ramp for collection vehicles. Part of the building required reinforced concrete retaining walls and foundations due to poor ground. The remaining external and internal walls consist of calcareous sandstone masonry. The lean-to type roof is tile covered and has two supporting trusses of wooden cross-tie construction. The transformer room required 54 cu m and is completely separated from other parts of the building. The 250 kw, three-phase transformer, providing 380 v current, is so planned that it will later serve the sewage treatment plant also. The plant is connected to a 10,000 v high tension line nearby.

b. Mechanical sorting:- Incoming refuse is dumped from collection vehicles into a bin that has a storage capacity of about 23 cu m. No pre-sorting occurs and even bulky garden wastes can be processed with the refuse. The contents of the bin are fed past a steel weighing belt to the first mill for coarse grinding. Here all the material is broken up into pieces of about fist size, including tin cans, glass, cardboard, paper, wood, textiles, etc. The heterogeneous material is now capable of being transported and separated. Ferrous metals are extracted in two stages and placed in containers for delivery to scrap iron dealers. Because of the preliminary grinding the tins are so reduced in volume that customary baling of scrap iron is unnecessary. The ground material, free of iron, is transported vertically upward through closed tubes by means of a Bühler chain carrier to a vibrating screen of coarse mesh which separates the refuse into two fractions.

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The screened material consists of heavy components which are pulverized between the two large rollers of a rolling mill. This portion contains practically all of the glass and ceramics which, because of their brittleness, have already been broken into small pieces by the primary grinder. The sieve residue (tailings) is comprised of all lighter material and fibrous components, chiefly paper, rags, wood fibers, leather, plastics, and rubber. Further grinding of this fraction is not absolutely necessary because these items do not hinder the composting; on the contrary, they improve the porosity of the compost heaps. But since the larger pieces, particularly of textiles and plastics, are not decomposed in the usual composting time of 3-4 months, they are undesirable in compost for purely esthetic reasons. The process therefore provides further reduction of the tailings in a fine grinder which also accomplishes good mixing. The milled and ground materials are brought together on the last chain conveyor and are discharged into a storage bin outside the plant.

The 12 electric motors operating the various machines and conveyors are controlled from a central panel located in the office room. A single manipulation on the control board suffices for complete automatic, step-by-step, operation of all motors beginning at the primary conveyor ahead of the weighing belt and primary grinder. If a stoppage occurs at any place in the plant, the safety switch of the motor involved shuts it off and with it all of the motors preceding it in the circuit. All conveyors preceding the blockage are stopped immediately while those following it work on in order to clear the system. The break is indicated by signal lamps and the entire plant is shut down after about 2 minutes. Servicing the plant is therefore foolproof and (automatic control) enables the operator to perform his duties in the composting area during the grinding operation.

Indicating and recording instruments are installed in the substation for control of motors for the main machines. The feed of the heterogeneous raw materials requires special control measures. Thus, the belt drive from the receiving bin is coupled with the primary grinder over an electronically-controlled maximal flow pilot relay. If the integration of flow and time exceeds a certain value, then the feed into the primary grinder is interrupted for 5-6 seconds. In this way the feeding points of the grinding process are instantly balanced and overloadings are avoided.

c. The composting:- The sorted and ground refuse, now only about a fourth of its original volume, is conveyed by simple means to the nearby composting slabs and is piled in windrows about 1.5-1.8 m high. Experience has shown that 2 to 3 turnings are needed with a decomposition period of 3-4 months. After this period the decomposition process is practically completed and the finished compost may be piled into larger piles or released to consumers. The repeated temperature rises which the compost undergoes after initial placement and after turning serve as a guarantee that the end product is hygienically unobjectionable. Experiments were made with adding sewage sludge (digested and fresh) to the refuse being composted which further increased the value of the compost. Some of the analyses of refuse compost with stable manure for comparison are shown in the following table. Periodical analyses of the Uzwil compost are conducted by der Eidg. Anstalt für Wasserversorgung, Abwasserreinigung und Gewässerschutz an der ETH Zürich.

	Refuse Compost	Stable Manure
Moisture content (%)	41.0	77.5
Volatile solids (combustible matter)(%)	20.4	17.4
Humus carbon (inert carbon) (%)	5.8	5.2
Active organic matter (%)	14.7	12.3
Alkali-soluble humus (%)	4.8	5.0
Total nitrogen (%)	0.6	0.4
Phosphorous as P_2O_5 (%)	0.36	0.21
Potassium as K_2O (%)	0.43	0.43
Calcium as CaO (%)	5.3	0.9
Magnesium as MgO (%)	0.65	0.23
pH value	7.6	7.3

The analyses are based on the fresh material (wet weight).

d. Results of the first year of operation:- The plant operation began October 12, 1956. For the first quarter-year the only refuse collected was from the village of Uzwil with 3,000 population and a weekly volume of a minimum of 22 and a maximum of 41 cu m. During the first three quarters of 1957, all domestic refuse and garden trash was received three times weekly from the three villages of Uzwil, Lower Uzwil, and Upper Uzwil with 8600 total population. The varying weekly amounts of the summer refuse are shown in the following table:

Amount collected weekly	Uzwil	Lower Uzwil	Upper Uzwil	Total
Minimum (cu m)	19	13	10	42
Maximum (cu m)	44	38	19	101

Average refuse density 160-275 kg/cu m

During the entire year, a total of 2,845 cu m of raw refuse was treated from which 9.3 tons (metric ton = 2,240 lb)or 1.6% by weight of scrap iron was obtained. The average volume reduction in grinding was 4:1 with a further 10-20% for the finished compost. The 180 cu m of raw compost produced Feb.-June was collected by the local gardening industry as a desirable material for hotbeds at a price of 5 Swiss francs/cu m from the plant. Buyers paid 15 Swiss francs/cu m from storage. Private gardeners can obtain the compost in impregnated bags of about 40 kg for 4.20 francs/bag delivered. The compost is of such good quality that there is a sure market within the community and outside interests can be served only to a modest extent.

The average power requirements per cubic meter of raw refuse process amounted to 7.4 kwh. With better plant use, greater quantities, and normal operation, the energy requirements will be considerably less. The conduct of operations, attendance, cleaning, maintenance, composting activity, and sale of material is taken care of by a single man. Maintenance of the machines is confined to oiling, cleaning, and replacement of worn parts of both grinders. Replacement requires only a little time. The duration of parts most exposed to wear in the grinders amounts to about 2,300 cu m or 3/4 year of running time.

The amount of refuse collected from the communities during the summer half of the year was 1.29 l/cap/day which corresponds approximately to the Swiss average including garden wastes. For a year with all three villages included (8,670 pop) about 4,100 cu m would be collected with compost production of about 1,000 cu m. The present plant may process 3 to 4 times this amount, or may be sufficient for a city of 30,000-35,000 population.

2. The Effect of Refuse and Refuse-Sludge Composts on Plants and Soils

by Dr. U. Springer, München.

> Report to the Expert Group on Fertilizer Analyses of the Association of German Agricultural Investigational and Research Institutes in Heidelberg, Sept. 1957. Reprinted from: Praktische Blätter für Pflanzenbau und Pflanzenschutz 1957, No. 5, with approval of Bayerischen Landwirtschaftsverlages, München 3.

While agriculture, horticulture, and viniculture have available various mineral and trace element fertilizers in unlimited amounts today, there is a known increase in scarcity of humus fertilizers. All civilized nations are seeking to find new sources of humus and even domestic refuse is used increasingly as the raw material for humus fertilizer. Reference is made to papers presented at the working session of der Arbeitsgemeinschaft für kommunale Abfallwirtschaft

(AkA) in Düsseldorf in July, 1957 which can be obtained in a brochure from the Secretary-General of the AkA, Dr. Straub, Stadtbauamt, Baden-Baden, or from the Secretariat of IRGR in Zürich*.

By refuse we mean the solid community refuse which is free from such substances as bottles, tin cans, shards, rags, leather, etc., possibly finally pulverized (hammermill, "raspel"). This fresh refuse (coarse or fine) is used raw only very rarely in Germany. Sanitary reasons generally require the decomposition of the material at 60-65° C. Numerous experiments with ornamental and food plants, some refuse-loving, some refuse-tolerant, and a few even refuse-intolerant, show that the sensitivity of the plants in the last two groups (carrots, onions, beans, berry bushes, etc.) is considerably lessened by means of composting. Planting refuse-loving plants (truck crops, cabbage species, tomatoes, etc.) soon after compost fertilization in the fall and following these by refuse-sensitive plants without organic fertilization or with moderate mineral fertilization is the most suitable practice in agriculture and gardening. This crop sequence proved good because of the excellent after-effect of compost fertilization. Because both fresh and digested sludges are relatively rich in humus and nitrogen, the making of refuse-sludge compost is occurring more and more and a higher value for refuse or refuse compost is achieved.

On particularly heavy soils the use of raw refuse with its greater pore space and lesser fixation of nutrients produces higher yields than use of refuse compost (according to the Bavarian Agricultural Institute for Plant Culture and Plant Protection). When discussing the action of refuse and refuse-sludge composts on plants and soils, we must differentiate positive and negative actions. Of course efforts in processing and disposal of refuse are aimed at reducing or removing the unfavorable effects.

First of the positive effects to be dealt with is the nutrient action of these composts. They contain the nutrients N, P_2O_5, and K_2O in similar amounts as in stable manure and its compost as well as smaller or larger amounts of lime and magnesium and all known micronutrients, especially manganese, copper, boron, molybdenum, and zinc.

Physiological solubility of N and P_2O_5 has been found, particularly by W. Sauerlandt, to average about 10-20% of the total nutrient substance, while potash is available to a very great extent (in sludge which has low potash other values might be somewhat greater). As compost fertilization is usually heavy, 500-1000 hundredweights (cwt) per hectare, considerable amounts of nutrients are applied (with 0.5% total N and an application of 1000 cwt, about 50-100 kg of soluble N). (Ed. note: the hundredweight, cwt, is 100 kg or about 220 lb instead of the 112 lb as assumed on p. 20 of Info. Bull. No. 1. The hectare is 2.47 acres). Thus, even without addition of mineral fertilizer, very good yields are obtained, particularly with truck crops. Because of the high lime content of compost (10-15% $CaCO_3$), the results are usually better on acid soils than on neutral to alkaline soils. Concerning P_2O_5, the least active of the basic nutrients, there is considerable fixation to the sesquioxide and to the lime which, according to Dutch experiments, permits large applications of compost to enhance the activity of the phosphoric acids of the soil and thus increase the yield. In the same experiments, the magnesium of the compost also appears to be very well assimilable by the plants. The favorable action of refuse compost in cases of deficiencies of boron, manganese, and copper in soil was learned long ago from sugar beet regions, as well as on soils which exhibit the heath-moor and dry spot diseases (blights). B. Teensma (Holland) obtained good results with potatoes using refuse compost on soils with trace element deficiencies.

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*See also the paper on the author "Feasibility of application of tests for evaluation of refuse composts".

Of more importance is the positive effect caused by the organic substances in compost, yet only the so-called "effective organic matter" (EOM) is considered, that is the difference between total organic substance (volatile solids) and inactive organic matter (humus coal). Their determination has been reported in Deutscher Landwirtschaftlicher Untersuchungs-und Forschungsanstalten No. 1, 1954. The EOM content in the dry matter must be at least 10%. The less completely decomposed composts used, as in Holland, for hotbeds and in refuse-sludge composts often have considerably higher values. The humus substances of refuse-sludge composts show a high degree of stabilization, mainly because of the higher lime content. Thus, in a 3-year field trial there was only a small decrease in decomposable carbon (E. Steigerwald and U. Springer, Zeitschr. f. Pflanzenbau u. Pflanzenschutz, 4,193, 1953).

The advantageous effects produced by the organic substances of compost in the soil are primarily of a physical nature. They act chiefly to improve texture, particularly in heavy soils, making tilling considerably easier after repeated applications of compost. Increased pore volume, air- and water-retention capacity are shown. By increasing moisture-holding capacity, a greater assurance of yield is achieved. Dutch observations have shown that compost contributes greatly towards prevention of erosion due to wind and water. Klenk (Weinsberg) also confirmed the prevention of erosion damage in vineyards after use of compost.

There are a few special effects of composts. I refer to results reported by Teensma on so-called soil exhaustion. When it is caused by deficiency in trace elements, the curative effect of compost on the basis of its content of these is understandable. Where soil exhaustion is due to infestation by parasites such as nematodes or by toxins, they may be successfully combatted with compost. How this is accomplished is still unexplained. Compost is also effective against potato scab, produced by the fungus *Actinomyces scabies*. This is remarkable because the pH of soil is raised by application of compost but potato scab is usually favored thereby. The successful use of composts as bedding in pigsties and chicken runs, in which better health and uninterrupted growth occurs, is interesting. Here antibiotic effects may come into play, especially as vitamin B-12 has been found in composts. These results, achieved in foreign countries, should be retested in precise experiments.

Concerning negative effects of refuse compost, the pH value is usually 7 to 8, sometimes up to 9. Danger of too great an alkaline reaction forbids the use of large or frequent compost applications to neutral or alkaline soils. Recent attempts have been made to lower the calcium carbonate content by addition of sulfur (conversion to calcium sulfate through biological processes).

Crop damage may appear if the compost contains excessive amounts of trace elements. This occurs mainly when winter refuse is the raw material. For example, the winter refuse of München (Munich) with 0.144% of $B(OH)_3$ and an application of 1000 cwt contains 144 kg of boric acid. The reason lies in the high micro-nutrient content, particularly of boric acid, in the lignite. In a Munich residential area with district (centralized) heating or electrical heating and where no coal ashes are to be disposed of, the boric acid content is only 0.0066%. As emphasized by the author at the AkA meeting in Düsseldorf, determination of toxic limits of the more important trace elements appears to be a very pressing problem. Exceeding the limiting values causes plant diseases to be reckoned with which are different according to the type of plant. The cost of possible crop damage due to excessive addition of trace elements is the chief drawback to more extensive use of composts. Yet fertilization with composts creates much less danger than fertilization with the raw refuse, particularly with winter refuse.

It is also evident that the use of sewage sludge from industrial cities in which the sewage contains strong plant poisons like chromium and lead salts, phenols, cyanides, etc. the greatest caution is needed. In controlled composting the presence of toxic organic substances, such as sulfides which have not been appreciably oxidized or microbially decomposed (due to harmful metals), the determination of injurious metallic effects is mandatory.

In former years, very high applications of refuse, particularly old refuse, were used such as 1000 cwt and more (amounting in bulk to over 1 cu m). To avoid the risk of excessive trace elements in such high application rates, it appears desirable to limit applications to not more than 500-600 cwt/hectare, at intervals of 2-3 years, especially because of the particularly desirable after-effects experienced by the Bavarian Agricultural Institute. Because these (smaller) amounts of compost, even in the year applied, may not be enough to give highest yields, it is supplemented by small to moderate amounts of N and P_2O_5 on nutrient-poor soils.

It follows that refuse compost, also refuse-sludge compost, is primarily a soil-builder but it also acts directly as a crop nourisher. At the working session of AkA in Düsseldorf, Schmitz expounded the standpoint that refuse compost should be termed as a means for soil improvement, which one is not duty bound to support. It is sufficient to state here that the testing of refuse compost according to requirements existing for fertilizers is not only a tedious but difficult task chiefly for the reason that we still do not know the toxic limits for the trace elements present in composts. We must attempt to establish tentative valid limiting values with factors of safety until time permits the ascertaining of more exact values. The use of factors of safety proves necessary because of factors of soil type, enrichment, weathering, time of application of compost which may exert considerable influence. Limits of toxicity would become particularly important if the industry should mix nutrient substances (NPK) with a compost base, thus producing an organic-mineral fertilizer. Concerning the addition of nutrients to refuse and refuse-sludge composts, this should be discouraged at present as the low economic value does not make it appear practical.

Research shows that a good compost is suited in a special way to combat the loss of humus threatened by extensive soil tilling and to raise the humus level of humus-poor soil with low (water-) retentive capacity. Recently in various nations, especially Germany, the problem of hygienically making composts from urban refuse and sewage sludge is being worked on energetically and successfully, and there is no doubt that these composts will attain an increasing importance in our humus economy in the coming years.

3. Refuse Compost in Poultry Husbandry by Engineer B. Teensma, Amsterdam.

At a meeting of the Dutch Division of the "World's Poultry Science Association" in 1952, an address was made by Engineer K. Bos on results of a new thick litter method in poultry raising which he had learned in America and which had been developed by Prof. Kennard as the "old built-up litter system". This address and the outstanding results achieved by Prof. Kennard caused extensive experiments with this thick litter method to be conducted in the Netherlands. Results were so favorable that this system has come into use throughout Holland. The "hygienische Methode" commonly used until the present, wherein the bedding layer (sand or peat bedding) had to be changed every 7 to 14 days, has been discarded almost everywhere.

In the thick litter method, hens and chicks are left in pens on a 30-50 centimeter thick layer of organic matter such as straw, corncobs, wood shavings, horse manure, peat bedding, and, recently, refuse compost. The fowls spend their entire life on this bedding, never being let into the open. The bedding may be used for 3-4 years without renewal, assuming that an intensive bacterial flora with heat production therein is correctly maintained. It is necessary to control the temperature of the bedding layer. If necessary the bedding layer can be turned (aerated) or fresh organic matter may be mixed with it. The bedding must not be too damp (danger of rot) which can occur particularly in winter in poorly aerated pens. A strong ammonia odor is an indication that the aeration is insufficient. But the bedding layer must not become too dry or the microorganisms will cease their activity. In this case the bedding must be sprinkled with water and then stirred up.

With proper use the following advantages are provided by this method:

(1) Labor saving. The bedding no longer has to be changed every 7-14 days. A thick litter bedding may be used for at least 3 years.

(2) The fowls always have a warm bedding which is of greatest importance, especially in winter. Thus fewer diseases occur. On bedding that is too cold the chicks tend to huddle too closely together and many victims of asphyxiation are found.

(3) Mortality is lower because fewer infectious diseases occur. The greatest danger in chick-raising is caecal coccidiosis, and most losses are traced to it. With the use of the deep litter method, coccidiosis almost never has a fatal outcome and the use of drugs, such as sulfonamides, is unnecessary. Ammonia is formed with the decomposition of chicken manure in the deep litter bed and serves effectively in controlling the oocysts of coccidiosis. Although chicks become infected with coccidiosis, the disease takes a very mild course. The chicks form antibodies which prevent later infections. Perhaps antibiotics also play a role in this connection but nothing is definitely known yet.

(4) Cannibalism subsides markedly. It frequently appears in poultry raising and can cause much damage. Why cannibalism fails to appear or is significantly less among chickens raised on deep litters is not understood. Perhaps the fowls on deep litter are occupied the whole day with scratching and picking, especially if feed is strewn on top of the litter. Because of the scratching, the animals have more exercise which is beneficial to their health.

(5) Better growth of fowls on the deep litter. In all experiments the weight of fowls raised on deep litter was at least 10% greater than that of fowls raised by the hygienic method. Ten-week old chicks raised on deep litter had the same weight as 12-week old chicks maintained on standard bedding in one experiment. Probably the animal proteins, also vitamin B-12, contained in deep litter play a significant role.

(6) Better results in brooders with eggs from fowls raised on deep litter. This factor may also be ascribed to animal protein factors.

(7) Space savings. The opinion prevailed until recently that chickens needed to run in the open with provision of at least 15 sq m/fowl, preferably on a grassy plot. The new deep litter method has shown that such runway is not only unnecessary but even undesirable as the runway area is eventually always infested with intestinal parasites (among others, coccidiosis and worms). The danger of intestinal infections is therefore considerably increased. The deep litter method has shown more advantage in maintaining chickens permanently in pens. Space requirements are barely 1 sq m for three hens and loss from infectious diseases is very considerably diminished.

The deep litter method is now generally used in the Netherlands and many poultry raisers use urban refuse compost for this because it is cheap and easily worked. Other materials such as straw, wood shavings, etc. are also mixed with the compost. As refuse compost contains valuable mineral components (phosphoric acid, lime, trace elements), it is particularly well suited for this purpose. After use in chicken pens, the compost has acquired very high fertilizing value and may well be sold. Experiments are in process in the Netherlands using raw refuse alone as a thick litter bedding. The material soon dries out because of the resultant high temperatures and must therefore be rewetted from time to time. Results to date are very promising.

4. The New Compost Plant at Duisburg-Huckingen in Operation

The Duisburg-Huckingen compost plant was officially placed in operation December 16, 1957 after a long trial period.

The Municipal Sanitation Office gives us valuable data in the following:

(a) History. Dumping refuse in canals, depressions, and the like has been forbidden for some time for the protection of two waterworks south of Duisburg. Composting was chosen as another means of disposing of refuse. As against incineration, this process has the advantage of lower construction and operating costs. Also, a very important means of soil improvement for agriculture is obtained with the compost. In selection of the composting process, preference was given to the biostabilizer system developed by the Dano Company at Copenhagen because this process permits addition of large amounts of sewage sludge and requires only a short period of operation. The only other compost plants in Germany, at Baden-Baden and Heidelberg, use other systems. Similar plants have been operating for some time in Denmark, Holland, and Switzerland. The Huckingen compost works is, however, the largest mechanical plant constructed to date.

(b) Method of Operation. Laden refuse trucks dump into receiving bunkers. Raw refuse is transported on apron and belt conveyors to the composting plant. Scrap iron is sorted out by magnetic pulleys, conveyed to a press, and baled. In the winter screens separate out the unwanted ashes. On the final sorting conveyors valuable and brittle materials are picked out by hend. The refuse is then conveyed to rotating drums (biostabilizers) and mixed with sludge. Biological decomposition starts with forced aeration and continuous rotation of the drums, converting the refuse-sludge mixture to raw compost in 4-5 days. After leaving the drums, the compost is freed of glass splinters, stones, rags, and otherwise useless substances by screening. The compost is then immediately given up to agriculture or is piled temporarily in heaps. Screen residues are taken to the nearest dump.

(c) Technical Data.

Collection area: About 140,000 population = 1/3 the City of Duisburg.

Capacity: Refuse about 200 cu m = 80 tons per workday; Sludge about 10-20 cu m/day; Scrap iron about 2 tons/workday; Compost about 50-60 tons/workday.

Building size: About 21 x 35 x 9 m = about 7000 cu m of enclosed space.

Size of the two biostabilizers: Length about 25 meters; diameter 3.5 meters; capacity about 250 cu m.

Installed motor power: About 200 kw.

Construction started: October 1956.

Completed: August 1957.

Construction costs: About 1.5 million German marks (about $357,000).

(d) First Operational Experiences. During the trial period a strong odor developed which caused annoyance. After construction of a water scrubber for the air from the biostabilizers, this difficulty was overcome (see also the brief reports in this issue). First analyses of the compost showed good results.

5. Brief Reports

a. Holland: The Second Compost Plant with Railroad Delivery.

Since 1931 the train (designated number 4711 in the Dutch railroad scheme) has hauled urban refuse from the Hague to the V. A. M. compost works at Wijster in the northern Province of Drenthe. In the years 1950 and 1951 refuse was added from Groningen (145,000 pop) and Zandvoort (15,000 pop), and Ameresoort (60,000 pop) completed a 30-year contract with the Waste Disposal Company V. A. M. last year.

The refuse quantity from these cities gradually became too much for the compost plant at Wijster so that a second plant had to be built. This was put into operation in 1955 at Mierlo near Eindhoven (South Holland) in a region with sandy soil upon which compost acts very favorably. At first the refuse from Eindhoven and a few neighboring communities (total pop 175,000) was handled but now the plant, second largest in Holland, has been provided with railroad delivery so that part of the refuse from the Hague can also be sent there. On August 2, 1957 the first refuse train was emptied from the new viaduct.

Plant capacity has been increased to 70,000 metric tons of refuse per year making about 50,000 tons of compost. Formerly the available refuse was insufficient for full capacity. Refuse is now transported to the plants at Wijster and Mierlo according to the need.

The composting plant at Mierlo uses the Van Maanen system which has been improved by experience in operation of the plant at Wijster. Advantages of this system are the relatively low investment (somewhat more than 2 million Gulden) (about $550,000) and the low operating costs. Production can be regulated to the market so that compost need not be stored for a long time. The plant produces standard compost for agricultural use, garden compost, and material for hotbeds (hot manure).

b. Germany: Odor Development at the Duisburg-Huckingen Compost Plant.

When a compost pile is undisturbed or not turned it gives off hardly any perceptible odor. Odors given off when the pile is disturbed are mild, moldy, not unpleasant odors in the outer layers, a sour unpleasant odor at greater depths, and an extraordinarily penetrating putrid odor in the center. This anaerobic odor, originating from oxygen-poor and oxygen-free regions of the compost pile, then vanishes astonishingly quickly as soon as oxygen is again accessible to it. The opinion of experts up to now has been that a completely aerobic process throughout its course was practically odor-free.

It was therefore an unpleasant surprise to all when the new Duisburg-Huckingen refuse-sludge compost works developed a quite penetrating odor despite the undoubtedly aerobic decomposition process. Atmospheric conditions in the area are certainly unfavorable (misty weather) and the nearest blocks of houses are scarcely 50 m from the plant which handles about 100 tons of refuse; nevertheless, the odor produced proved stronger than was expected. The odor could not be eliminated with either ozone or simple aeration, but disappeared completely with electrolytic combustion. The latter process, however, entails considerable operating costs for fuel so that another way had to be found.

Engineer Stahlschmidt of the Dano Company in Copenhagen, after thorough experiments at Chur (Coire) Switzerland, developed a process of air circulation combined with a two-stage cooler and water scrubber and installed it in the plant at Duisburg. The plant was again in operation in the beginning of November 1957 and subsequently operates practically without odor. An official investigating commission, consisting of representatives of the neighborhood, press, health officials, and officials of the City of Duisburg, confirmed this on November 23. As an interesting attendant phenomenon, it should be mentioned that the decomposition process in the drums is apparently accelerated by the new air circulation procedure.

c. China: Composting of Refuse and Night Soil.

The World Health Organization (WHO) reports: One point in the public health program of WHO is the improvement of refuse disposal techniques, or the collection, treatment and disposal of wastes from cities and villages. As a step in this direction, the Chinese Government with WHO help has constructed in the City of Ping-Tung (Taiwan) an experimental refuse composting plant in which various methods can be tested and compared with one another. At the WHO public health seminar held recently in Taiwan, proposal was made to enlarge the Ping-Tung experimental plant so that the large amount of night soil from dry privies could be incorporated with it. These studies will include the collection, treatment, and disposal of night soil for agricultural purposes, as well as its storage with regard to sanitary importance.

It has been shown that insanitary treatment and disposal of night soil can lead to spread of disease. But to date in China no method of disposing of such matter in a sanitary manner has yet been found. Only partially dry material is suitable for composting. If it is too wet, anaerobic processes of decomposition predominate and no temperature rises result. Yet these (rises) are important for elimination of pathogenic microorganisms. The obvious solution lies in the mixing of the wet fecal matter with dry refuse and composting them. But in Taiwan, Japan, and other countries, the quantity of night soil collected far exceeds that of the dry refuse so that a surplus of wet wastes exists which must be treated otherwise. Thus experiments have been proposed by WHO, such as the pasteurization of the wastes with subsequent utilization or centrifuging the materials with final composting of the concentrated night soil.

6. Discussions

a. Rebuttal of Discussion Remarks of Dr. Gerretsen in Information Bulletin No. 3, pp 11-12.

In general it is not customary to use the term "glühverlust" (loss by burning or volatile solids) instead of "organischen Substanz" (organic substance or organic matter) because the volatile solids as everyone knows may even include water of hydration, volatile matter which results from the decomposition of certain organic salts, and probably also mineral carbonic acids. I have therefore suggested the concept of "wirksamen organischen Substanz" (W.O.S.) (active organic substance) in opposition to (total) organic substances and have reported the method for their determination many times (e.g. in Information Bulletin No. 1 of IRGR).

As to what is meant by the term "Humuskohle" (humus carbon), I took that term from the science of soils. It stems from the famous Swedish humus expert Sven Oden (see his classic work "Die Huminsäuren" /The Humic Acids/, 1919). As this humus carbon may include, besides coal and coke remnants, other worthless organic matter such as leather, plastics, I use the broader term "inaktive organische Substanz" (inactive organic substance).

Concerning the C/N-ratio, it should be stated that the value C_w/N_t (active carbon/total nitrogen) might well be used in reference to composts in general. It may be assumed generally that the N-content of the humus carbon is very small and can therefore be disregarded. I am also of the opinion that as far as possible the ratio C_w/N_w should be determined, wherein N_w is the difference between N_t and the N of humus carbon. This N_w value, however, is by no means identical with physiologically active (soluble) N which is considerably lower in general.

- - - - Dr. U. Springer, München.

b. Rebuttals to Remarks of the Secretary Concerning the Separation of Hard Substances in Information Bulletin No. 3, pp 12-13.

Concerning the separation of hard substances by air (ballistic) separation, we would like to direct your attention to the fact that an apparatus of that kind was built many years ago, even before Dano experimented with it at Copenhagen or Chur, in various "Raspel" plants of Dorr-Oliver, Inc. (Schiedam, Delft, Sneek, etc.). In Heidelberg and Blaubeuren (Germany), too, this type of separating apparatus exists. These "Eutscherbungsmühle" (de-sharding mills) have no connection as such with the "Raspel" (grinding process but are provided at almost all such plants as an additional apparatus for de-sharding the materials discharged from the rasp. These mills were originally developed by the V.A.M.

We might add that flinging the particles to obtain ballistic separation does not lead to noteworthy results if the particles have a similar initial velocity. Although particles of like mass, like form (i.e. small spheres), and like initial velocity, but of different specific gravities, will pass through different flight parabolas due to proportionately greater air resistance of specifically lighter particles, like form of particles is not encountered in practice. The air resistance and also the flight parabola is therefore too much dependent upon the shape of the particles.

For proper separation it is thus necessary to give the unwanted hard particles a greater initial velocity. This is accomplished in the V.A.M. separator mill by the impact of heavy, rotating railroad rails against the particles. The soft particles, generally organic, being less elastic, attain a lesser initial velocity. A further advantage of this method is that unwanted lighter particles which are also elastic, such as pieces of rubber and cork, are also generally thrown out.

- - - - Engineer H. Wurfbain, Amsterdam.

The method of ballistic separation was in daily use at the V.A.M. composting plant at Wijster in 1934 and 1935. Later other methods came into use. In 1951 and early 1952 at the Schiedam compost works of V.A.M. a hammermill for flinging out for ballistic separation was newly constructed. This is now generally used with a roller crusher at 6 plants in Holland. The hammermill breaks up some of the hard particles but the ballistic action is effective.

- - - - W. A. G. Weststrate, Amsterdam.
(Managing Director, V.A.M.)

7. Technical Literature Forwarded to the Secretariat

a. Information Journals of the N. V. Vuilafvoer Maatschappij "V.A.M." (Waste Disposal Company V.A.M.) Jac. Obrechtstraat 67, Amsterdam.

An investigation reported in the December 1956 issue indicates that cellulose decomposition in refuse composting proceeds considerably faster at 30° C than at 70° C. It is concluded from this that no danger exists of too rapid breakdown of organic matter at higher decomposition temperatures.

In the February issue two examples of trace element deficiency in sandy soils are mentioned which were accidentally discovered when field experiments were plotted. There was question of deficiency in boron and copper. Outward symptoms were not in evidence for the experimental plantings (potatoes and wheat) but experimental treatment with borax and copper sulfate gave significantly increased yields of 13.6 and 19.2%, respectively. Probably trace element deficiency is more widespread than commonly supposed. The investigations also established that loss in yield through trace element deficiency may be prevented by the use of refuse compost.

Two continued articles in the February-April 1957 issues discuss the effect of grass mulch on soil structure in arboriculture on marshlands. Increased earthworm activity, penetrating the soil a depth of 1.5 m, increased the water-holding capacity and soil aeration for favorable plant-root growth.

Results of refuse compost treatment on a few tree species (American oaks and beeches) are described in the June 1957 number. The experimental planting was treated with compost 15 years ago. Yearly growth rings subsequently were three times as wide as previously. The increased growth is maintained undiminished today. An address by Dr. M. Oostenbrink to the Agricultural College in Wageningen on the influence of nematodes on soil production capacity is described in the same issue. An abstract from the work of Engr. Jac. Kortleven concerning the effect of refuse compost on plants is found in the August 1957 number.

b. Aktuelle Fragen der Müllbeseitigung, Müllaufbereitung und Müllverwertung, Züricher Symposium 1955 (Present questions on refuse removal, treatment and utilization, Zürich Symposium) 174 pp. Publ. R. Oldenbourg, München 1957. Brochure 28.40 German marks (about $6.75).

European experts reported on research findings concerning "where we stand" on questions of refuse removal, treatment, and utilization at the summer 1955 symposium in Zurich held at the Eidg. Technischen Hochschule. The foundation of IRGR followed this symposium. The addresses of the symposium were published in French in the "Schweiz. Zeitschrift für Hydrologie, Vol. 17, No. 2, 1955 (Birkhäuser, Basel) and this publication is the German version. This volume excellently and concisely depicts the present status of refuse technology and compost utilization as given in 14 papers.

c. De Fraja Frangipane, E.: Preliminari allo studio di un impianto per il trattamento dei materiali di rifiuto solidi urbani (Preliminary considerations for establishment of a treatment plant for municipal refuse). Extract from Ingeneria sanitaria, No. 6, 1956.

The author describes the most important processes of refuse treatment, compares the economy of the procedures, and attempts to evaluate the processes as to sanitary importance. He places particular value on the recovery and utilization of refuse matter. The conclusion is that refuse, by its relatively high content of organic matter and plant nutrients, is well suited to use in agriculture to maintain and increase chemical and physical soil productivity.

d. Kortleven, J.: Proeven met stadsvuil compost
(I) invloed van stadsvuilcompost op het gewas.
(Studies with urban refuse compost (I) Influence of urban refuse compost on plant growth) Publ. landbouwkundige onderzoekingen No. 62.12 'S-Gravenhage 1956, 245 pp.

Extensive investigations of the short-term action of urban refuse compost on various experimental crops are reported. The experiments are being continued to study the long-term action.

The initial effect of compost appears when it can eliminate deficiency phenomena in the soil, chiefly a deficiency in nutrient materials. The effect can be negative in the case of overdosing certain elements, nil with optimum nutrients, and positive with nutrient deficiency. Fresh or slightly decomposed compost strongly fixed nitrogen in the soil during the first half-year after its use. Decomposed compost, however, gave more favorable results. The author confirms the findings of Gerretsen and others that the use of unripe compost in autumn shows better results than the use of ripe compost in the spring. Apart from gardening, the most favorable area for use of compost is the field structure of light soils. The greatest initial effect of compost is shown in green-manure crops. Truck crops react more strongly than do cereal crops. Peas and beans, among others, occasionally give negative results.

e. Seifert, A.: Der Kompost, eine Fibel für kleine und grosse Gärtner, für Bauern und Landwirte (Compost, a primer for small and large gardeners, farmers and agriculturists). Publ. Henns Georg Müller, Krailling bei München, 88 pp, 1957.

This booklet is written for the practioner in small operations. The nature and action of compost and its preparation and use in agriculture are described. The author is concerned primarily with composting of stable manure with other organic substances. Statements on the use of compost in horticulture, viniculture, and gardening reveal rich experience.

f. Springer, U. Ueber die Verwertung städtischer Abfallstoffe in Gartenbau und Landwirtschaft. (On the utilization of municipal refuse in horticulture and agriculture) Reprint from "Disinfektion und Gesundheitswesen", 4/5, 1957.

Summary: By treating refuse-loving and refuse-tolerant plants with fresh refuse, definite increases in yield could be achieved (an average of about 20% as against unfertilized crops). These increases in yield became significantly higher with the use of refuse compost, highest with refuse-sludge compost (30 and 45%, respectively). The after-effects were particularly superior in the case of truck crops and species of Brassica (cole). Considered economically, refuse compost cannot compete with mineral fertilizers. However, the author points out the importance of the humus components in the various forms of refuse as a possible means of increasing soil productivity, but the monetary value of these factors alone is difficult to establish. The author emphasizes the necessity for achieving useful evaluation of these substances by quick labor-saving methods while avoiding costly time-consuming field and pot experiments. In no case should the favorable results already obtained in the field of refuse disposal be discarded and half-way measures adopted. Gradual success is being achieved in preparation of various kinds of refuse and its compost into productive, hygienically unobjectionable means of soil improvement which will take a permanent place in soil management. (Reprints of this article may be obtained from: Dr. U. Springer, stellv. Direktor der Bayer, Landesanstalt für Pflanzenbau und Pflanzenschutz, München).

g. Horstmann, O.: Erfahrungen mit der Kompostanlage Heidelberg (Experiences at the Heidelberg composting plant) Reprint from "Mitteilungen des Verbandes Kommunaler Fuhrparks-und Stadtreinigungsbetriebe" Special number: "VI. Intern. Kongress für Städtereinigung, Frankfurt, Oktober 1957." (Sixth International Congress on Public Cleansing).

Insanitary conditions and long hauling distances to the present dumps, lack of additional possible disposal sites for refuse, and contamination and hardening of groundwaters forced the city administration of Heidelberg to study the refuse problem seriously. Because of the marked interest of gardeners in a compost rich in organics and the determination that composting is cheaper than refuse incineration, even in the event of incomplete consumption of the compost, the city administration decided to construct a large experimental plant for refuse composting and to operate it for 5 years. It was the consensus that too few reports of this type of operation existed and such data must be gathered over a period of years. After 5 years a full-scale composting plant is planned for construction at a location near the city and, if possible, also in the vicinity of a new sewage treatment plant. Meanwhile, the question of utilization and sale of compost should be sufficiently answered so as to provide as small a risk as possible in establishing the final plant. This is an intermediate report after 2½ years of plant operation. It describes operating and composting techniques as well as the important point of sale of the compost. These experiences are valuable as is the fact that the author does not conceal the negative aspects.

The Secretariat of IRGR will send reprints to interested persons as long as they last.

h. Buck, K.: Frischmüll and Müllcompost zur Verbesserung und Düngung des Bodens (Fresh refuse and refuse compost for improvement and fertilization of soils) Report of der Deutschen Landwirtschafts-Gesellschaft (D.L.G.) a collection and evaluation of literature on agricultural use of fresh refuse and refuse compost delivered at the session of des Arbeitskreises für landwirtschaftliche Verwertung von Siedlungsabfällen der Acker- und Pflanzenbauabteilung der D.L.G. at Braunschweig-Volkenrode, March 22, 1956 (1957).

Summary: A crop injury from domestic refuse compost will not occur when heavy applications, furnishing more lime than the soil requires, are avoided. Compost should only be used for refuse-loving and boron-requiring plants. Considered refuse-loving are; potatoes, fodder- and sugar-beets, grain (maize), sunflowers, cruciferous plants, lettuce, spinach, endive, tomatoes, cauliflower, and certain ornamental plants. Ground and screened refuse should be applied to soil three to four months prior to planting, preferably in the fall. Refuse compost may be added immediately at sowing. The different composition of summer and winter refuse compost must be considered. Successes with refuse as fertilizer are traced to the combined action of nutrients (NPK), lime, organic matter, trace elements, and rare earth constituents. Research results with refuse composts and, particularly, the important question of economy in their use, will be reported later.

The Secretariat of IRGR will send reprints to interested persons as long as they last.

i. Welte, E., Sahm, U., and Marx, Th.: Steigende Gaben von Altmüll und Ertrag verschiedener Kulturpflanzen (Increasing applications of aged refuse and yield of various cultivated plants). From the Institut für landwirtschaftliche Chemie der Biologischen Bundesanstalt für Land- und Forstwirtschaft, Berlin-Dahlem. Gesundheits ingenieur, No. 9/10, 1957.

Summary: Refuse earth (aged refuse) from the Berlin-Spandau dumps was tested in increasing application rates up to 30 kg/sq m as an admixture to a nutrient-poor, slightly loamy, sandy soil of the Dahlem experimental fields in concrete boxes and in field experiments with tomatoes, alfalfa, potatoes, celery, and onions. It showed a definite nutrient effect in all cultivated plants except tomatoes. Yield increase in field experiments was highest for potatoes (78%). Alfalfa also showed great capacity for utilizing the minerals found in the refuse, which may be due to high lime requirements of alfalfa coinciding with high lime content (13.3% CaO) of the old refuse. Yields initially increased with increasing applications of refuse. With amounts of 10 kg/sq m and over, however, distinct depressions became noticeable, although the yield always remained above that of the untreated test plots. Applications of mineral fertilizer in amounts similar to refuse fertilization acted variably. By application of refuse a limited effect was shown with potatoes and alfalfa while considerable yield increases were achieved with celery and onions in field trials. Mature refuse earth (aged refuse) can be applied with definite yield-increasing effects on light sandy soils with correct choice of cultivated plants.

j. Arbeitsgemeinschaft für kommunale Abfallwirtschaft (AkA): Arbeitstagung in Düsseldorf vom 4.-6. Juli 1957 (Meeting of AkA at Düsseldorf) 108 pp. Once again this richly illustrated report of lectures is referred to.

(Ed. note: Here are listed the main addresses and discussions at the AkA meeting as the table of contents. Inasmuch as the program of the meeting was given in Info. Bull. No. 2 and as Bull. No. 3 gave summaries or abstracts of nearly all papers, the contents are not repeated here.)

This report (German) may be obtained for 12 Swiss francs from the Secretariat of IRGR or directly from the AkA (Oberbaurat Dr. H. Straub, Stadtbauamt, Baden-Baden).

k. Parrakova, E.: Zneskodnovanie pevnych odpadovych latok na zdokonalenom smetisku a kompostovanim (Making solid wastes safe by controlled refuse maturing and by composting). Bratislavske lekarske listy, Rocnik 37:11. 1957, Bratislava.

The author concerns herself with the composition of solid urban wastes and their innocuous disposal through controlled deposition and composting. The controlled refuse heaps of the transverse type (Ed.

note: windrows comply with sanitary requirements under the conditions given. Plantings on refuse heaps of this type also enrich the otherwise orderly raw waste surface and improve the appearance of the community. In composting urban wastes without previous preparation (grinding?) of the materials the author had unsatisfactory results.) (Ed. note: An Indian composting method recommends plantings of legumes on composting refuse for nitrogen fixation and enrichment of the compost when it is turned).

l. Parrakova, E.: Die geeignetste Art der Abfallstoffbeseitigung für Landsiedlungen (Czech title not given). (The most suitable method of refuse disposal for rural communities) Hygienické problémy vystavby sidlist, Symposion komunalni hygieny, Praha, 1956.

The quality of refuse of a selected rural community was determined by mechanical, chemical, bacteriological, and helminthological analyses. Changes were also observed over the years. Composition of solid refuse in this community did not differ essentially from urban refuse in quality. The difference quantitatively was chiefly with respect to inorganic constituents. Differences in organic matter content between urban and rural refuse were not outstanding because, in agricultural areas, the organic refuse (vegetable and kitchen garbage) were used as feed. Controlled composting of refuse turned out very well in these experiments. The thermophilic decomposition occurring in refuse heaps (windrows) was adequate with regard to sanitary requirements.

m. Pfeiffer, E.: Anleitung für die Kompostfabrikation aus städtischen und industriellen Abfällen. (Instructions for the manufacture of compost from urban and industrial refuse) 122 pp, Gustav Fischer, Publ., Stuttgart, 1957.

The author initially describes the "Pfeiffer-Process" he developed with a "starter" and based on the need for guiding and controlling the process of decomposition by means of the addition of bacterial "starter". Not only a shortening of time of decomposition but also an improvement in the quality of composts is attained thereby. The book contains an abundance of worthwhile examples and experiences from and for practice. Numerous results of analyses of the various raw materials and composts, as well as a good review of the technical literature, complete the text.

(Ed. note: An English version of this manual is: "The Compost Manufacturers Manual - The Practice of Large Scale Composting" E. E. Pfeiffer, Publ: The Pfeiffer Foundation, Inc., 226 South 16th St., Philadelphia 2, Pa, 137 pp, 1956).

n. Others Listed

Rohde, G.: Die Kompostierung von Schweinekot (The composting of pig manure) Reprint from: "Mitschurin-Bewegung", No. 24, 1956.

Demortier, G.: Essais de bonification des sables incultes de Campine à l'aide de déchets urbains (terres de bruyères de la commune de Lommel) (Trials in the improvement of uncultivated sands of Campine with the aid of urban refuse /heaths of Lommel community/). Reprint from the "Revue de l"Agriculture", 10th year, No. 3, March 1957.

Krige, P. R.: A Study of Modern Methods of Municipal Waste Utilisation and Conversion to Compost. National Chemical Research Laboratory, South African Council for Scientific and Industrial Research. Reprinted from "Municipal Affairs" (see issues September to December, 1955).

Fischer, F.: Das erste Wiener Müllkompostwerk. (The first Vienna composting plant). Reprint from "Der Aufbau", Publ. Stadtbauamt Wien, November 1956.

Caspari, F.: Städte stiften Segen (Cities create abundance). Reprint from "Waerland Monatschefte", No. 8, 1956.

Caspari, F. and Horstmann, O.: Naturnahe Landschaftspflege durch Stadtkompost (Close to nature care of land through municipal /refuse/ compost). Reprint from "Die neue Landschaft", No. 11, 1956.

8. Reports of the Secretariat

Discussions: The possibility of discussions in our Information Bulletin exists as before. We ask that brief contributions be forwarded to the Secretariat.

Reprints: The address of Engr. R. De Groote, Staatliche Versuchsanstalt für Gartenbau, Ghent, Belgium on the subject "Analysis and evaluation of the quality of refuse compost" (German) at the AkA meeting in Düsseldorf (1957) unfortunately could not be included in the report (see 7, j). Reprints can be had from the Secretariat as long as they last. (See also Info. Bull. No. 3, pp 3-7.)

The Secretariat is in a position to distribute the following reprints:

Teensma, B.: Experiences with the use of municipal refuse compost in the Netherlands. (German) Address at AkA meeting, Düsseldorf, VKF-Mitteilungen, No. 13, pp 72-78, 1957.

Horstmann, O.: Experiences at the Heidelberg compost works. (German) VKF-Mitteilungen, No. 14, pp 36-40, 1957.

Rohde, G.: Composting pig manure. (German) Mitschurin-Bewegung, No. 24, 1956.

Steigerwald, E. and Springer, U.: Further experiments with refuse, refuse compost, and refuse-sludge compost, 1950-1952. (German) Zeitschrift für Pflanzenbau und Pflanzenschutz, Vol. 4, No. 5, 1953.

Steigerwald, E. Refuse-sludge compost as a means of soil improvement and fertilization. (German) Praktische Blätter für Pflanzenbau und Pflanzenschutz, No. 6, 1956.

Buck, K.: Fresh refuse and refuse compost for improvement and fertilization of soils. (German) Mitteilung der Acker- und Pflanzenbauabteilung der Deutschen Landwirtschafts-Gesellschaft, Frankfurt a. M., 1956.

Anon: Composting with refuse and sludge. (German) Ministerium für Landwirtschaft, Weinbau und Forsten des Landes Rheinland-Pfalz, 1956.

Stahlschmidt, V.: Development of the Dano biostabilizer method for composting refuse and sludge. (German) Städtehygiene, No. 12, 1956. (See Abs.: Info. Bull. No. 2, p 13)

Straub, H.: The sewage treatment and composting plants of the City of Baden-Baden. (German) Das Gas- und Wasserfach, 92, No. 24 (Wasser), 1951. (See Abs.: Info. Bull. No. 2, p 12)

Allenspach, H.: Experiments with combined treatment of sewage sludge and (street) sweepings. (German) "Plan", No. 3, 1956.

Braun, R.: The (street) sweeping problem in Switzerland. (German) "Plan", No. 3, 1956.

Straub, H.: Composting of community wastes -- A report on experiences at the Baden-Baden plant. (German) Gesundheits ingenieur, 77, Nos. 19/20, 1956. (See Abs.: Info. Bull. No. 2, p 12)

Straub, H.: Making compost from sludge and refuse (German) Report in: Abwassertechnischen Vereinigung e. V., No. 1, 1949. (See Abs.: Info. Bull. No. 2, pp 12-13)

Hörler, A.: On the question of approval of kitchen refuse grinding apparatus (kitchen grinders). (German) Schweiz. Zeitschr. f. Hydrologie, 17, No. 2, 1955.

International Research Group on Refuse Disposal: Information Bulletins No. 1, 2, and 3 (French and German).

INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)

Information Bulletin No. 5

August 1958

1. Preliminary Notice: International Congress on Disposal and Utilization of Town Refuse, Scheveningen, Netherlands, April 27-May 1, 1959, Under the Auspices of the International Research Group on Refuse Disposal (IRGR).

The IRGR, Zürich, joined by the German Arbeitsgemeinschaft für kommunale Abfallwirtschaft (AkA), and working committees from the Netherlands, France, Switzerland, and, recently, Italy, plans an international congress in the Netherlands in the spring of 1959. Proposed date is April 27 to May 1, 1959 (Ed. note: dates have been confirmed). The congress to be held in Scheveningen is authorized by the Dutch Ministry of Agriculture and will permit information exchange by experts of European and extra-European nations. The tentative congress program with participants from Germany, Holland, England, France, and Israel includes the following lectures:

Development and Significance of Refuse Utilization in the Netherlands.
New Developments in Technique of Refuse Preparation.
Specific Technical Problems of Refuse Preparation.
Biological Processes in the Conversion of Town Refuse.
Influence of Humus on the Mineral Intake of Plants.
Long-term Effects of Refuse Compost.
Utilization of Refuse Compost in Subtropical Countries.

Congress participants (will) have the opportunity to study the most important Dutch refuse disposal plants as afternoon excursions will be made to these plants. Organization of the congress is by the International Agricultural Centre (1, Gen. Foulkesweg) Wageningen, Netherlands (Ed. note: to which interested persons should write for the complete program and for hotel accommodations. Participation fee for congress, excursions, registration, and printed matter is 70 Dutch florins, about $18.45, per participant). Arrangements are planned for an international exhibition of refuse - and sludge - handling equipment for both composting and incineration. A special program will be provided for the ladies. The detailed congress program will be published in a subsequent Information Bulletin.

2. The Refuse Composting Plant in Edinburgh by N. G. Wilson, Lighting and Cleansing Dept., Edinburgh (Scotland).

Like any other city, Edinburgh also has its problem of refuse disposal. Intensive growth of the city and suburbs has sharply increased the volume of refuse so that the existing plants are unable to handle the material. Refuse dumping sites are scarcely available now and covering soil is difficult to procure. Edinburgh's problem was to find the best and most economical method of refuse disposal and utilization.

The usual methods have been used to date in the three city refuse plants: mechanical screening-out of dust and ashes (which make up the greater percentage of our refuse), magnetic separation of iron components, hand sorting of discard materials. The rest was burned. The chief problem was now to

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find a substitute for the incinerators for which construction and operation costs are very high. Besides it was idealogically desirable to return the organic refuse to the soil.

Before World War II thorough studies in Edinburgh showed that composting of sorted refuse was feasible and that there was a demand for compost. The methods used then still offered a few difficulties and requirements of area and time were quite high. These difficulties can be eliminated by the Dano biostabilizer method developed a short time later. In July 1955 at the city Seafield depot an experimental biostabilizer of 145 cu m (190 cu yd) capacity was built which has since handled the rejected material from an existing city refuse plant. The plant operates 8 hours/day and 5½ days/week. The raw refuse handled amounts to an average of 70-75 tons/week with a compost yield of 35 tons and a like quantity of noncompostable refuse. To each ton of material fed to the biostabilizer are added 270-360 liters of liquid, either sewage sludge or 2% ammonia water from the gas works. Maximum temperatures in the biostabilizer reached 60° C. Following is an analysis of the refuse compost made by the "Edinburgh and East of Scotland College of Agriculture":

Moisture	44.9%
In the dry matter:	
Organic matter	48.8%
Ash	51.2%
Nitrogen	1.1%
Nitrogen in organic matter	2.3%
pH-value	7.0
C/N ratio	25.1

Demand for the refuse compost is large, particularly in agriculture, truck gardening, and by private garden owners. The selling price is 35 shillings ($4.90) per ton. Bagging and delivery are additional. A special sales organization has not been needed to date.

It was recently planned to build another refuse composting plant to handle 140 tons of raw refuse per day. Encouraged by good results in the experimental plant, we decided to equip the new plant with two biostabilizers each with an operating capacity of 222 cu m (290 cu yd). Financial savings from such a plant, considering yearly loan and interest charges as well as reduction in payroll, reveal a considerable economic advantage compared to the usual incinerator, even if the compost has to be distributed free of cost. However, a considerable income is expected from the annual sale of 3,500 tons of compost. The plant is expected to start operation in the middle of this summer.

Another biostabilizer plant will be built at Powderhall (works) and will replace the old incinerator which is in very bad condition. The experimental plant at Edinburgh has awakened the interest of the most distant experts; visitors from more than 40 different nations have inspected it.

3. The Preparation and Utilization of Municipal Wastes in Hungary by Dr. G. Farkasdi, Giessen.

In Hungary, which lost a large part of its cattle herds after World War II and which had a sharp decline in fertility of the land due to intensive cultivation during the wartime economy, a strong interest soon appeared for the preparation and utilization of community wastes by composting. In contrast to most western countries, this interest arose from agricultural needs and, therefore, contributes to the fact that no special difficulties exist for the sale of compost in Hungary.

The need for sanitary collection, treatment, and appropriate utilization of municipal wastes urged public works and community management officials to find a satisfactory solution. Only isolated developments occurred up to 1949 in this respect. In a few cities private projects existed for collection and treatment of city wastes (usually only night soil, market- and slaughterhouse-refuse). They operated with primitive hand implements and could comply with only a few sanitary requirements.

After the general taking over of private enterprise by the State in 1949, appropriate officials saw the need of finding a comprehensive solution in the field of urban waste disposal. Refuse collection and sewage disposal have since been the duty of the appropriate municipal department consequently causing no immediate problem. Collection of night soil in towns partially or not served by sewers and of industrial wastes, as well as suitable treatment and utilization of all municipal refuse, however, still await solutions.

On the urgent recommendations of agriculturalists, city administrators, and public health officials, the government decided to establish a national organization for management of all organic wastes, apart from agricultural wastes. This organization was instructed to deal with all town wastes and municipal refuse such as sewage sludge, night soil and pig manure from the large feeding pens (all mixed with peat), as well as refuse from open markets, stores, slaughter- and cattle-houses, and industrial organic wastes. The treatment and utilization of these wastes also fall within the scope of the assignment. The organization, led by a central administrative board in Budapest, was quickly established country-wide. Plants were established in 1949 for the first time in the suburbs of the nation's capitol and in larger cities of the provinces. Plants were systematically established in all urban areas during the next few years and in 1957 about a million tons of valuable organic fertilizer for agriculture were produced by 50 plants. Peak production has not been reached yet by far. In order to supply the plants with the necessary amount of peat, a national peat production association was formed which took over peat mining enterprises at the same time.

In 1952 the production and newly created management problems, in addition to those caused by the complicated bureaucracy customary in communistic countries, reached such magnitude that they could no longer be overcome by one central board. Consequently, a decentralization and simultaneous reorganization was undertaken. Four branch organizations were founded, each with authority in a quarter of the country (North, South, East and West Hungary). These authorities controlled all peat, compost, and sewage treatment works within their area and were largely autonomous but were guided by a central organ called "Trust für Erhaltung und Steigerung der Bodenfruchtbarkeit" (literally: Trust for Maintenance and Enhancement of Soil Fertility). All sale of commercial fertilizer was also placed under this Trust, partly to eliminate possible undesirable competition from the commercial fertilizer industry and partly to synchronize production requirements of the various areas. Although the Trust fulfilled its duties satisfactorily, in one year it fell victim to so-called "Rationalisierung" (rationalization) common in the nations of the Eastern Bloc. Its administrative duties were taken over by the Ministry for Light Industry. The four peat- and compost-production associations were still further decentralized; the individual plants were grouped according to agricultural districts and placed under local industrial management organizations.

For solving scientific problems, planning new plants, and furthering development of existing plants, an Institute for Peat and Fertilizer Research was founded under the direction of the famous soil biologist Dr. L. Kreybig. This research institute also took over consultation to the plants and quality control of the products; it has only advisory and planning functions, not directive authority. All proposals must be submitted to the Ministry and are activated through the appropriate district authority.

This side-organization complicated and slowed down the administration of management but fitted better into the communistic management plan and continues to the present time. Founding the research institute, however, may be considered as an exceptionally appropriate measure as it unites the best experts of this region, coordinates their activities, and ensures that their results are put into practice.

The Institute is organized into three divisions: (1) Peat division, (2) Organic fertilizer division, and (3) Plant management division. The peat division has two subdivisions: one for surveying and mapping peat deposits, and one for laboratory investigations. The organic fertilizer division has three subdivisions: chemical, microbiological, and agricultural. The plant management division has two subdivisions: one for planning and investiture questions and one for plant inspection and consultation.

The most important duties of the peat division were (sic): location and appraisal of new peat deposits (extent, thickness of bed, possibility of draining, mapping, etc.); laboratory investigations to determine the quality (organic matter, ash, humus-matter content, heating value, etc.) and possible uses (heating or fertilizing).

The duties of the organic fertilizer division may be divided into research and investigations. Only a few of the more important tasks of the former will be mentioned here.

I. In the field of compost production:

(1) Testing of composting processes by chemical, microbiological, and plant physiological means in their individual phases. This should particularly answer the following questions:

(a) Relationship between differences in aeration, temperature and microbial numbers and activity on one hand, and the losses in total solids, organic matter and nitrogen, as well as increase in humus content, on the other hand.

(b) The influence of varying aeration and temperature on the survival of pathogens, intestinal parasites, and weed seeds.

(2) The mixing of sewage sludge and other organic wastes with urban refuse.

(3) Composting night soil with frozen peat refuse in winter.

(4) Composting wastes difficult to decompose, such as rice hulls, reed (thatch) wastes, hemp and flax wastes, etc.

(5) Effect of seeding with finished compost or microbial cultures.

II. In other fields:

(1) Further processing and refining of composts.

(a) Making mixed organo-mineral fertilizers, some granulated, and studying their effect on soil microflora and on individual cultivated plants.

(b) Making so-called "Erdtöpfen" (potting soil) and finding the best possibilities for its use in horticulture.

(2) Determining the best possible use of "Bunkerde" (exposed strata of peat).

(3) Plant physiological research with all products.

The laboratory investigations are conducted by the chemical and microbiological subdivision; the plant physiological research (pot and field experiments) by the agricultural subdivision.

The second large activity includes the serial analyses of finished products for quality control and for possible inclusion of new types of refuse with regard to their value and suitability for composting.

The plant management division has a more administrative type of duty which will not be discussed here.

The bulk of the research is devoted to regulation of operational practice and the Ministry establishes priority of investigational problems with the approval of the Institute directors.

Individual plants are differently organized according to their production and work methods. Some plants make only compost and some also produce other products (granular fertilizers, potting soils, etc). The domestic refuse of medium- and large-size cities is hauled to the larger local plants, processed and utilized; that of smaller towns, health resorts, garrisons to smaller, so-called "Wanderbetrieben" (mobile plants). The latter are mobile, motorized units of large plants which periodically collect and compost the domestic refuse from an area about 100 kilometers in diameter. Processing refuse from smaller communities can be profitably conducted by means of these periodic collections.

The composting plants are located throughout the country on sites fixed by the public health officials beyond the limits of city dwellings and with direct access by road or barge. Their size varies with the quantity of refuse to be processed. They are only slightly mechanized (conveyors, motors and pumps); still frequently use horse-drawn vehicles and hand labor. The plants themselves have charge of collecting night soil and sewage sludge; all other community and industrial wastes must be transported by those responsible for the waste at their expense to the nearest compost works, in compliance with a government regulation.

The night soil is mixed with peat wastes and composted at least 21 days in low windrows. In this time--established by regulation--the pathogenic microorganisms and parasites are claimed to be destroyed. As the windrows (piles) may not be disturbed for the three weeks, they are covered with a thin layer (about 10 cm) of finely sifted aged refuse for protection against fly infestation and for better decomposition of the outer layers.

After the 21 days the night soil-peat is sold or generally mixed with other wastes and further composted. The proportions of individual components of the mixture are specified by the research Institute according to prior analyses. Analyses considered are quantitative yield, C/N ratio, density, water and ash contents, microbial activity, etc. General guidelines: As far as possible in mixtures of plant and animal wastes, nitrogen-rich materials should be mixed with cellulose-rich materials, coarse with fine, wet with dry, and microbe-rich with microbe-poor refuse. If necessary, the materials are inoculated with liquid manure during preparation. A C/N of 30-35, water content of 45-55%, and ash content far below 50% are sought. The compost-mixture is piled into long windrows, generally with a bottom width of 3 to 5 m and a height of 1.5 to 2.5 m without pre-treatment. Aeration occurs through vertical, also frequently horizontal, air channels. The larger windrows are turned if the high temperature begins to drop. The decomposition time is 5-9 months, according to the nature of the materials and size of windrows. A dependable test easily conducted is still lacking for determining the degree of maturation, so experiments were started in 1956 which should contribute to solving this problem.

The refuse of large cities is a special problem as its heterogeneous composition obviates the need for mixing other waste matter (such as sludge) and the daily mixture is so great that it often must be segregated. Before composting city refuse, the discards (metals, glass, bones, etc.) are sorted out, otherwise treatment proceeds like that for mixed composts. Screening also is provided before disposal. Winter refuse is not composted because of its high ash and cinder content.

The finishing plants should be given special mention. These generally make two products: mixed organo-mineral fertilizers (composts enriched with superphosphate, the so-called "Organophosphat") and granulated organo-mineral fertilizer (composts enriched with phosphorous or potassium salts and granulated, so-called "Biosuper" and "Biokali"). Both are used as mixed fertilizers and contain, in addition to trace elements, readily soluble as well as slow-acting P_2O_5 and K_2O. Moreover, the granules have the further advantage that, as a result of their low moisture content (about 8 to 10%), they can be easily transported and distributed and may be stored longer. The production of granulated fertilizer (to date about 30,000 tons yearly) is increasing. After completion of all new, highly mechanized, plants, it will be increased to an expected 100,000 tons. The potting soils, as a third "finished" product, should soon be made in greater amounts from peat and compost with various additives, finding a good market among horticulturists.

There are no particular selling difficulties for disposal of compost fertilizers in Hungary. This is primarily due to the fact that farmers need organic fertilizers and do not take a stand against the use of compost fertilizers. Secondly, in the nationally controlled planned economy, production and demand are largely synchronized to each other, no competition existing between the commercial fertilizer and the organic fertilizer industries, especially now because insufficient chemical fertilizer can be produced. Selling price of compost fertilizer is set so low (4.10 Forints/100 kg. = the cost of 1.25 kg of bread or of 1.2 l of milk) (about $0.35), that its purchase is made profitable to all farmers. This low sale price is far below present manufacturing costs which are somewhat more than double that amount. The difference is compensated for by a state subsidy to the production plant.

Efforts are being made to so lower production costs through further mechanization and improvement of working methods that payment of the subsidy can be discontinued. Further cost reductions are sought in avoiding unnecessary transportation charges by locating plants as closely as possible to the communities and industries producing refuse and also centrally with respect to peat mining operations and the horticultural and vinicultural operations. Specifically, production should cover first the needs of the gardener and those of horticulture and viniculture for organic fertilizer and secondarily that for agriculture which is largely able to satisfy its own requirements by means of stable manure, green manures, etc.

In summary, the inter-connected system for collection, processing, and utilization of all urban wastes of the entire nation has proved exceptionally good for the general and agricultural economy. Following the good results achieved in Hungary, the disposal of refuse in Czechoslovakia should soon be organized similarly.

4. Inauguration of the Composting Plant at Dantumadeel, Netherlands by W.A.G. Weststrate, Amsterdam.

It has long been customary to compost refuse with night soil in various communities in North Holland, mostly agrarian regions. The mixing and piling is done very inconveniently by hand. Preparation of piles and emptying buckets of feces are not only unpleasant, insanitary tasks, but the resultant compost also exhibits a few disadvantages: It contains too many shards and hard objects such as slag (cinders), its moisture content is too high, and the pathogenic microorganisms are not absolutely eliminated because the temperature does not rise or it rises only a little in the decomposition process. For these reasons the product has been hard to dispose of in recent years, although its fertilizing value was good.

Attempts are being made to eliminate these disadvantages at the new composting plant at Dantumadeel, a community of 10,000 in the north of the province of Friesland and, indeed, with an approved simple installation that required no large investment. Construction costs are so low that it is feasible for most communities. Of course manual labor is not entirely eliminated, but allowance can be made for it considering the small quantities of materials to be processed. Manual labor could nevertheless be entirely avoided by the installation of a hopper with a movable bottom as customary in larger plants.

Plant Description:

The collected domestic refuse and street sweepings are dumped on the floor of the receiving room. A laborer with a fork or shovel throws the waste onto a conveyor belt at the same time sorting out objects that are too large or difficult to process, which are afterwards burned in a small wide-mouthed oven. A second laborer removes iron, bones, other metals, textiles, and glass from the conveyor belt. The belt conveys the remainder to a hammermill, of a type used in England for half a century, for pulverizing the refuse. The mill has heavy hammers of manganese steel and is very strongly built. Refuse is forced through a grating with openings of about 4 x 6 cm so that it leaves the mill pulverized and practically free of shards. Below the hammermill an electromagnate removes any remaining pieces of iron.

The ground refuse can be decomposed in windrows. After 3-4 mouths the compost can be offered for sale. The fresh ground refuse may also be sold as hotbed manure or be used for composting with stable manure.

But communities that collect night soil, as is the case in Dantumadeel, can empty the feces buckets into a tank with an overflow. The liquid phase flows into a second tank from which the product is sold to neighboring farmers. The sludge is brought by a screw conveyor into a mixing trough where it is mixed with the pulverized refuse. The mixture has a moisture content which assures thermophilic decomposition.

The principle of the dumping apparatus for the feces buckets is worthy of mention. They are emptied automatically by a pressure lever operated by their own weight and are washed by a strong stream of water. The buckets need only to be put in and taken out. Capacity of the apparatus: 1 ton in 13 seconds.

Some Figures on Operations:

The hammermill capacity is 2,000 kg/hr (8 to 10 cu m). The mill operates 3 hours per day to grind the refuse from 10,000 population. Total motor capacity is 70 HP of which the hammermill is 50 HP and the flushing pumps 12 HP. The equipment cost was 45,000 Gulden (about $11,850) for processing refuse, and 25,000 Gulden (about $6,580) for processing night soil and mixing it with the ground refuse. The plant is simply but adequately built. The project planners found a process by which small communities can produce a good, shard-free compost with little manual labor.

The collection of night soil by buckets in the dwellings is outmoded and insanitary; it should be eliminated as soon as possible. However, as long as it still operates in a few dozen communities of our country, we will try to make the best of it.

The "Compost" Foundation (Stichting "Compost") in Amsterdam was advisor to the plant construction. It was inaugurated in December 1957 by the Director-General for Agriculture, Engineer W. A. van der Plassche, who remarked that this compost plant could serve as a model for other rural communities. It is very important that the smaller communities also make compost to help fill the great need for it. Such a plant is advantageous in small communities because the transportation distances from producer to consumer are smaller.

The compost works is located in a sparsely-settled area surrounded by meadows. This region has cattle-raising and agriculture. Farmers, and gardeners farther distant, show great interest in the good, shard-free product. The plant can also be classed as successful from the standpoint of sanitation as well as of the purchaser.

5. The Determination of Domestic Coal in Refuse Compost by Dr. F. C. Gerretsen, Groningen, and W.A.C. Campen, Maastricht, Netherlands.

The content of more or less (completely) burned household coal in urban refuse compost varies from about 6 to 30%, according to whether it is summer or winter compost. It is self-evident that these coal residues cannot be included with organic substances useful to agriculture, as nevertheless happens if the content of organic matter in the compost is determined solely by the method of determining loss by combustion (Ed. note: volatile solids determination). It is extremely important in the evaluation of a municipal refuse compost to be able to determine the content of domestic coal separately from the effective organic matter. The great resistance of coal against widely different chemicals offers the possibility of conducting this type of analysis.

Hitherto the decomposable organic substances (protein, humus-substance, lignin, hemicellulose) were separated by boiling with dilute sulfuric acid and hydrogen peroxide and the residue extracted with dilute NaOH or NH_4OH. The remaining cellulose was dissolved in Schweitzer's reagent (ammoniacal solution of cupric hydroxide) with domestic coal and ashes finally remaining. The carbon content of this was determined by combustion.

Although fairly accurate results were obtained with this method, it was shown that in a simpler manner as good and sometimes better results can be achieved if the decomposable organic substances are separated by the usual method with Scharrer-Kürschner reagent (a mixture of trichloracetic acid, acetic acid, and nitric acid). Thus protein, lignin, humus-substance, and most of the hemicelluloses are removed in solution. The residual cellulose can be separated either with Schweitzer's reagent or by hydrolysis with dilute sulfuric acid. Both methods give good agreement, therefore the method that can be more conveniently performed may be used.

The treatment with the mixture of acids of Scharrer-Kürschner reagent appeared to us to be not without misgivings at first as it was revealed that anthracite and (bituminous) coal are not entirely resistant to this reagent. It may be possible that the coal is partly oxidized to oxygen-containing complexes. To clear this up, a number of samples of dried anthracite and coke of different origin were boiled in the same way as the composts with the Scharrer-Kürschner mixture, were then cooled and allowed to stand 1½ hours at room temperature in H_2SO_4 (80%) and finally, after tenfold dilution with water, were boiled for 1 hour for cellulose and remaining hemicellulose hydrolysis. The results are shown in the following table:

Table I

Changes in Weight of Pulverized Anthracite and Coke after Treatment with Scharrer-Kürschner Reagent and Hydrolysis with H_2SO_4.

		gain or loss in weight in % of original dry materials	
Anthracite			
Source:	Wilhelmina Mine	9.1 8.9	+ 9.0
	Dominoler Mine	12.0 12.5	+ 12.3
	Donetz Basin	4.5 4.8	+ 4.7
Coke			
	Gas coke	-2.9 -2.0	-2.5
	Petroleum (cracking) coke	-2.0 -3.1	-2.6

It is thus shown that the combustible substances are not entirely resistant to the treatment with Scharrer-Kürschner reagent; the anthracite gains weight, the coke loses it. These changes were caused in one case by weight increase through partial oxidation, in the other by weight loss through complete oxidation to CO_2. If all domestic coal in compost was anthracite, then in a given case a factor of about 0.9 could be used. In urban refuse compost, however, most of the coal residue consists of coke and of anthracite more or less converted into coke; unchanged anthracite is only rarely present and then only in small amounts, and besides the weight gains of this are partly compensated for in the foregoing treatment by the weight losses of the coke. Winter compost contains an average of 25 percent domestic coal and it is anticipated that the accuracy of the determination by means of this process is only a little influenced by it.

The domestic coal content is finally determined by combustion of the residue remaining from the Scharrer-Kürschner reagent and hydrolysis with sulfuric acid.

Nevertheless, it is emphasized that in this way only the combustible content of the coal is determined, not the ashes and not nearly the total content of domestic coal residues. In the agricultural uses of composts it is without significance whether both components are known or not. In the indirect determination of organic substances usually effective in agriculture, it is likewise unimportant as the content of these substances is calculated by subtracting the total ash content of the compost, the weight of coal and the carbon dioxide that may possibly be present from the weight of the original dried sample.

In table 2 the results of a few determinations are shown, performed according to the simplified method above. Comparative values are also given as obtained by the old method of F. C. Gerretsen (boiling with H_2SO_4 and H_2O_2, extraction with NaOH, extraction of cellulose with Schweitzer's reagent, and combustion of the residues).

Table 2

The Content of Domestic Coal* in Various Composts in % of Dry Substance (determined by two methods).

	Method A	Method B
Winter urban refuse compost V.A.M.	29.5	30.1 (I)
Summer urban refuse compost V.A.M.	14.2	13.5 (I)
Compost with sand	11.2	11.9 (II)
Winter urban refuse compost No. 759	30.4	32.5 (II)
Compo I	28.1	28.9 (II)
Compo II	30.0	30.6 (II)
Winter urban refuse compost V.A.M.	29.5	29.8 (II)
Compost from Best	6.3	6.3 (II)
Urban refuse compost from Doetichen	23.7	22.3 (II)
Urban refuse compost from Caberg	21.8	21.7 (II)
Compost from Central Institute C.I.L.O.	13.3	15.1 (II)

*Included are domestic coal and other charred components that may be present.

Method A - H_2SO_4 plus H_2O_2; NaOH; Schweitzer's reagent.

Method B - Scharrer-Kürschner hydrolysis with H_2SO_4 (I) or Schweitzer's reagent (II).

Considering the unhomogeneity of the materials, the results show quite good correlation although obtained by different methods. Method B is somewhat simpler and faster and has been inaugurated as the standard method in the Netherlands.

Description of the Method.

(a) Reagents.

(1) Scharrer-Kürschner reagent: 50 gm of trichloracetic acid is dissolved in 1.5 l of acetic acid (70%), to which is added 124 ml of nitric acid (65%) (S.G. at 150°C: 1.4) and is diluted with 70% acetic acid to 2 l.

(2) Schweitzer's reagent: 200 gm $CuSO_4 \cdot 5H_2O$ is dissolved in 1.5 l of hot water and an equivalent amount of ammonia (± 120 ml, 25%) is added for precipitation of the $Cu(OH)_2$. If too much NH_4OH is added, some dilute H_2SO_4 is added. The color of the supernatant liquid should be blue-black. The precipitate is allowed to settle, is decanted, then washed 3 or 4 times with distilled water and filtered with vacuum through a Buchner funnel with a hard filter. The precipitate is now dissolved again in 25% ammonia (3-4 hr agitation) and must contain at least 1.5% Cu. As a control, 5 ml are dried at 105° C and ignited at 600° C. The residue is weighed as CuO.

(3) If dissolving the hydrolyzed cellulose with H_2SO_4 is preferred to Schweitzer's reagent, then 80% H_2SO_4 is prepared by diluting concentrated H_2SO_4 with distilled water to a specific gravity of 1.727 (at 20° C).

(4) Acetone.

(5) HCl, 1.5 N.

(b) Determination.

(A) The air-dried sample is pulverized to powder in a ball mill, dried, and 1 g is mixed in an Erlenmeyer flask with 80 ml of Scharrer-Kürschner reagent and boiled for 1.5 hr. It is filtered while hot through a Gooch crucible with thin asbestos layer. The residue is washed once with the reagent, then with hot water until the acid is eliminated, and finally with 50 ml of acetone; then dried.

(B_1) The residue, consisting of domestic coal, cellulose, hemicellulose, and ash, is placed together with the filter and 100 ml of Schweitzer's reagent into a beaker. Covered with a watch glass, the mixture is allowed to stand for a day and is shaken now and then. It is again filtered through a Gooch crucible with asbestos mat. It is washed with dilute Schweitzer's reagent, with 1.5 N HCl, with distilled water to eliminate acid, and finally with acetone. It is then dried and weighed.

(B_2) Instead of B_1, the residue of A may be hydrolyzed by allowing it to stand for 1.5 hr at room temperature in a beaker with 50 ml of 80% H_2SO_4. It is then diluted to 500 ml with distilled water and boiled for an hour in a flask fitted with a reflux condenser. It is filtered while hot through a Gooch crucible with asbestos mat, washed with distilled water until free of acid, finally washed with acetone, dried, and weighed.

(C) After treatment B_1 or B_2 it is ignited for 2 hr at 900° C and is weighed. The difference equals the domestic coal content.

Remarks:

(1) If the material to be tested contains much fatty matter, it should be removed at first by extraction.

(2) Schweitzer's reagent does not keep indefinitely. As soon as filter paper is no longer quickly dissolved and a somewhat viscous fluid is formed which is difficult to filter, the reagent should be renewed.

(3) Domestic coal is only incompletely burned at 600° C, therefore it should be ignited for 2 hr at 900° C.

(4) The so-called useful organic matter may be readily calculated by subtracting the weights of domestic coal, ash, and CO_2 from the original dry weight.

6. Literature Received at the Secretariat

a. Voss, N. - Untersuchingen über Ertragleistung, Mineralstoff-und Humuswirkung von Müllkompostund Müll-Klärschlamm-Kompost. (Investigations of yields, effects of mineral matter and humus with refuse compost and refuse-sludge compost) Thesis from Agrikulturchemischen Institut der Rheinischen Friedrich Wilhelm Universität Bonn, Dr. H. Kick, Director.

Summary: To test production yields and the effects of mineral matter and humus with refuse products, pot, cement bed (plot), and field experiments in vegetable-growing were conducted with refuse-sludge compost from the Baden-Baden plant and with refuse compost and pulverized raw refuse from the Heidelberg plant. An experiment with refuse-sludge compost from Baden-Baden, sludge and "biohum", both from Bonn had indicated the suitability of these substances in the recultivation of lignite pit-mining areas at Neurath.

The report gives a review of the literature and description of the experiments. The compost application was based on the nitrogen content, assuming one-fifth of the total nitrogen to be active (effective) and a similar amount of mineral nitrogen was applied in the control of (comparison) experiments. The mineral fertilizers were superior due to better availability of the nitrogen in the case of the shorter growing periods (up to 8 weeks) as measured by yields of the initial plants in the pot and plot experiments. In the case of longer growth periods in field trials with red- and sugar beets, the same or higher yields were achieved with the refuse-sludge compost as compared to mineral fertilization. In later plantings results were still more favorable with the composts because of nitrogen-loss in the mineral fertilization. The refuse-sludge compost was superior in all instances to the refuse compost. The fresh ground refuse with a C/N of 27 (after deduction of humus-carbon) resulted in damage and diminished yields chiefly because of microbial nitrogen fixation. Increasing applications up to 200 tons (metric) per hectare of refuse-sludge compost and to 115 tons of refuse compost (dry weight in each case) brought increasing yields except in the case of refuse-sensitive bush beans. However, production yields of the smaller applications were relatively better, i.e. by comparison to corresponding mineral fertilization in each case.

The refuse products used contained 21 to 32% total, or 12 to 21% active, organic matter by dry weight. Total nitrogen was 0.4 to 0.7%, P_2O_5 was 0.3 to 0.8%, and K_2O was 2.1 to 2.4%. The refuse-sludge compost showed the highest nutrient content, raw ground refuse being lowest, and refuse compost in between. The pH values were 7.8 - 8.0 for the compost, up to 9.3 for the raw refuse. Refuse products contained 6.8 - 7.8% basically effective substances. Total boron content was about 93-113 parts per million of dry weight of which 70-80% was soluble in hot water. While tests for organic matter and lime content by various methods and determination of C/N give criteria for evaluating composts, the determination of total nutrients is not enough to give reliable estimates of the effective (active) nutrient substances.

The total N of refuse-sludge composts during the year applied is only 10-15% effective as compared to mineral fertilization with nitrogen availability to the plants equal to 100%. The phosphate content of composts increased the supply above that of lactate-soluble phosphate in the soil even in later years, over that obtained by mineral fertilization. Available potassium was especially high in soil treated with refuse. After one year considerable potassium enrichment existed in the soil but it disappeared during the second year. In all instances the pH of soil was raised by compost applications. However, the plants set out did not show any indication of acute alkalinity damage.

The plant contents of K, Na, Ca, and B were higher with refuse-product treatment than with mineral fertilization, at least at the beginning of growth. Excepting boron in the case of bush beans, these substances in refuse did not act detrimentally to beets, brassica species and, presumably, also spinach, leeks, and other vegetables. Yet the overall effect of these water-soluble salts in the refuse appears unfavorable as white cabbage yields could be increased by more than 49% by water extraction of refuse-sludge composts. Also, best results of compost treatment occurred on well-buffered soils in the case of salt-loving, boron- and sodium-tolerating, beets. Here, even on lime-containing soils, applications of compost up to 200 tons/hectare (dry weight) could be made.

The refuse products raised the alkali-soluble humus content of soil by about 0.1-0.2%, the pore volume by 2.5-5%, and the water-content of soils in dry spells by 0.3-3.8%. In recultivation trials on filled lignite pits at Neurath, refuse-sludge compost improved soil structure but brought no greater beet yields than mineral fertilization did.

Possibilities for better results with refuse compost fertilization were considered finally. However, the costs of compost use were pointed out as being disproportionately higher than mineral fertilization for the same increase in yield and may be economically practical only in rare instances such as in soil improvement projects.

b. Buck, K. Herstellung von Müllkomposten und Müll-Klärschlamm-Komposten und Prüfung ihres Düngewertes. (Making refuse and refuse-sludge composts and testing their fertilizing value) From the Institut für Pflanzenernährungslehre und Bodenbiologie der Landw. Hochschule Hohenheim, Dr. K. Maiwald, Director. Reprint from "Zeitschr. f. Acker- und Pflanzenbau", 105(4) 409-442, P. Parey, Publ., Berlin-Hamburg, 1958.

Summary: The Institut für Pflanzenernährungslehre und Bodenbiologie der Landw. Hochschule at Hohenheim, on commission of the Federal Ministry for Ernährung, Landwirtschaft und Forsten, has conducted extensive experiments at the municipal refuse composting plants at Heidelberg and Baden-Baden. The following summarizes the interesting report on these experiments:

The carbon-nitrogen ratio of fresh, ground Heidelberg summer refuse is 26: to 29:1; that of fresh winter refuse is 30: to 35:1. These ratios were reduced to 20: to 22:1 during a 3½-month decomposition period. Turning of the piles during composting did not effect the process. Thermophilic decomposition of sludge mixed with winter or summer refuse resulted in even lower C/N. Winter refuse lost practically none of its nitrogen but lost 40% of its carbon.

Unground summer refuse is composted at the Baden-Baden plant. Raw refuse wetted with a liquid, digested sludge or water, has a C/N of 14 to 15.4 after 7 months of decomposition. Turning, aeration, and even the addition of sludge had no effect on this ratio. Winter refuse compost has the lowest nitrogen content (about 0.25% of wet weight); summer refuse compost was about twice that amount, somewhat higher still in the case of refuse-sludge compost. Dry solids content of refuse compost was between 60 and 70%. Phosphoric acid and potash contents of summer refuse compost were about 0.6% of the dry weight. Winter refuse compost contained about 0.4% phosphoric acid and 0.3% potash in the dry weight. The nitrogen and phosphorous contents were increased by the addition of sludge. Refuse composts and sludge contain 11-13% basically-active substances by dry weight (calculated as $CaCO_3$).

Heidelberg summer refuse compost and Baden-Baden summer refuse-sludge composts produced moderate increases in yield of potatoes in field trials. Complete mineral fertilization gave the highest yields. Two different Heidelberg winter refuse composts showed only slight increases in yield compared to "ungedunkt" (unfertilized) pots. By turning piles during composting or by aeration, the fertilizer value of the composts was not improved. These results were confirmed by pot experiments. Trials using stable manure, decomposed for only a month, showed yields between (those of)summer and winter refuse composts. Summer refuse and refuse-sludge composts acted the same in field trials as in pot experiments if the applications contained the same proportion of nitrogen. On testing the economy of fertilizers used, it was revealed that mineral fertilizers produced the greatest gain, only a small gain being obtained with summer refuse composts. The use of winter refuse compost and purchased stable manure was associated with losses.

Coal and lignite ashes are ballast and lower the value of refuse compost as fertilizer. The amount of ashes discarded depends on room heating and therefore on the average daily temperature. It is therefore proposed that each refuse compost be marked with the average daily temperature at the time the refuse was discarded in order to have an approximate measure of its content of coal ashes.

In pot trials with corn (maize) the effect of refuse compost even with high applications was weak and could not compare to that of mineral fertilizer. A nutrient-deficiency study in pot trials showed that N, P_2O_5, and K_2O must be applied together if normal plant growth and high yields of plants are desired. A fresh ground refuse with C/N of 35 fixes soil nitrogen and reduces yields. On subsequent plantings of mustard, the compost acted similarly if not still weaker. Formerly raw refuse gave higher yields on the second crops. In this experiment, the mustard suffered severely from boron deficiency in the rows under mineral fertilization which was further accentuated by lime. In the rows with combined refuse compost and mineral fertilizer, no boron deficiency appeared and only these rows showed high mustard yields. Summer refuse compost raised the pH value of the soil little, (winter) refuse compost somewhat more.

The author concludes:

(1) Mechanically pulverized raw refuse, after a decomposition period of about 3½ months, is utilizable as compost. Unground raw refuse requires a decomposition period of about 6 months. Turning the refuse during composting is not necessary for a better effect on the plants.

(2) Addition of digested sludge to refuse increases the nitrogen content. Less refuse-sludge compost is needed to produce the same fertilizing results than refuse compost. The sludge is however probably loaded with inert material (ballast).

(3) Summer refuse compost might find good use wherever people are dependent on the purchase of stable manure, as in truck and private gardening. Summer refuse compost is cheaper than stable manure but acts just as well. The use of 200 to 400 cwt/hectare of summer refuse compost is to be recommended. Whether the refuse problem as a whole can be solved on the basis of this limited use appears questionable. Refuse compost, however, does not compare economically at this time with the fertilizing measures of intensive agriculture (mineral fertilizers, locally-produced stable manures and composts, and green manures). Nevertheless there are possibilities of making the production and marketing of refuse composts cheaper.

c. Bourdier, L. Du fumier pour le Vignoble* (Fertilizer for vineyards). Agriculteur d'Anjou, December 1957.

The author, an Engineer of the Services Agricolas du Maine et Loire à Angers, discusses the use of refuse compost in vineyards. Following are extracts from the article:

The author stresses the maintenance of humus in or addition of humus to the soil of vineyards. In most such soils the humus content has dropped below the critical point and it is essential that it be raised. There are five possible ways of providing humus in vineyards: use of mushroom fertilizer (decomposed manure as used by the mushroom-raising industry); stable manure; compost of straw, horse manure, liquid manure, and ammonium sulfate; compost of grape wastes (marc); and compost of refuse.

Use of raw refuse in vineyards is rejected, not only because of the extra labor for sorting but unusable components, but also because treatment with refuse apparently promotes the spread of a fungus disease (coniocybe pallida). The latter was shown in 1957 in the vineyards of Loire-Atlantique when viniculturists used only slightly decomposed refuse from Nantes. The use of mature refuse compost is expressly recommended (in amounts averaging 20 tons per hectare) in order to assure the maintenance of humus in the vineyards economically. Refuse compost of the city of Paris could be bought in 1956 in Angers at these prices:

20-ton lot: 2,750 French francs/ton.
10-ton lot: 3,380 French francs/ton.

d. Jaag, O. Aktuelle Probleme der Müllkompostierung (Present problems of refuse composting). Sixth International Congress for Public Cleansing at Frankfurt a.M., October 15-18, 1957.

The author outlines the problems of refuse disposal and specifically urges the consideration of a rational, economical method of refuse disposal that takes into consideration protection of both surface and ground waters and the landscape. Mention is made of the embittered struggle between adherents of refuse incineration and those of refuse composting, indicating that arguments are not always purposeful and objective. It is unrealistic to recommend refuse incineration to a community that is not large enough to operate such a plant economically; and, vice versa, it would be erroneous to build a composting plant if no possibilities exist for the use of compost.

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*Received from: Mr. G. Doubrouchkess, French Committee of IRGR, Paris.

The author, after giving definitions, nature, quantities, and values of discarded solid waste materials, describes the various refuse treatment systems and the results of the investigations of the Eidg. Anstalt für Wasserversorgung, Abwassereinigung und Gewässerschutz concerning the preparation and composting of equivalent amounts of domestic refuse and digested sludge. A city or group of smaller communities has an interest in being able to provide one procedure for coping with the total amount of refuse and sludge discharged within the area of its water shed. Based on experiments performed at the composting plant at Rüschlikon (Switzerland), this is possible where certain prerequisites are met.

The possibilities of use of refuse compost for reconditioning of worn-out lands, and in forestry, viniculture, horticulture, and poultry raising are discussed.

e. Jaag, O; Walker, H; Allenspach, H; and Braun, R. Müllverwertung (Refuse utilization). Reprint from the Neuen Züricher Zeitung, Tech. Supp., 24 pp, 19 ill., June 18, 1958.

Dr. Jaag describes the community problems in planning and conducting refuse removal and utilization. H. Walker discusses the status of refuse incineration in Switzerland with emphasis on experiences from the incinerator at Bern. H. Allenspach describes the processes of refuse and sludge removal and R. Braun reports on the possibilities of utilization of refuse composts.

f. Harrar, A. Humus, Bodenleben und Fruchtbarkeit (Humus, soil life, and fertility). With 22 ill. and tables, Bayerischer Landwirtschaftsverlag Bonn-München-Wien, 1957.

Contents: Natural humus (origin, properties); Life comes from stone; How can humus be replaced? How is it prepared? (from urban wastes, agricultural wastes); Newer viewpoints of agriculture (humus economy, use and disadvantages of mineral fertilizers); Problems of soil improvement (making sterile soils fertile, Rhizobium humus, structural improvement, restoration of wastelands); Renewal of agriculture after installation of life in the soil; crop increases and soil protection; Organization of humus economy; General remarks and analyses; Explanations of statements by experts presented in the text.

Although many of the hypotheses and views presented in this book give rise to critical discussions, nevertheless interesting experiences gathered in Mexico are recorded by the author. The significance and use of the method she developed for quick decomposition of compost (inoculation by a special culture of fermenting organisms) are described in detail.

7. Information from the Secretariat

The following reprints are still available from the Secretariat: (Ed. note: Here 21 articles are listed of which all except the following have been included in previous IRGR Bulletins).

IRGR. Information Bulletins No. 1-4 in German and French.

Jaag, O. Aktuelle Probleme der Müllkompostierung (Present problems of refuse composting). Vortrag VI. Internationaler Kongress für Städtereinigung in Frankfurt a.M. vom 15.-18. Oktober 1957. (See item 6, d. this Bulletin).

Jaag, O; Walker, H; Allenspach, H; and Braun, R. Müllverwertung (Refuse utilization) Reprint from the Neuen Züricher Zeitung, Tech. Supp., 24 pp, June 18, 1958. (See item 6, e. this Bulletin).

Böhme, L. Kompostierung von Klärschlamm nach dem Verfahren der "Natürlichen Kompostierung". (Composting sludge by the method of "Natural Composting".) Repr. from: Die Deutsche Landwirtschaft, No. 12, December 1957.

Buck, K. Herstellung von Müllkimposten und Müll-Klärschlamm-Komposten und Prüfung ihres Düngewertes (Making refuse and refuse-sludge composts and testing their fertilizing value). Repr. from: Zeitschrift für Acker- und Pflanzenbau, 105 (4), 409-442, 1958. Cost: 1.20 Swiss Francs. (See item 6, b. this Bulletin).

Rohde, G. Die festen Abfallstoffe der Stadt; Uebersicht ihres Aufkommens, ihrer Beseitigung und Verwertung. (The solid wastes of cities: Review of its collection, treatment, and utilization) (See source below).

Rohde, G. and Mibus, G. Die natürliche Kompostierung der Stadtabfälle, Empfehlungen auf Grund der in Gross-Berlin gesammelten Erfahrungen. (The natural composting of municipal wastes, recommendations based on experiences in Greater Berlin). Both papers in one reprint from: Städtebau und Siedlungswesen, short reports on research projects and communications from the Forschungsinstitut für Städtebau und Siedlungswesen der Deutschen Bauakademie, No. 7, 1957.

INTERNATION RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)

Information Bulletin No. 6

January 1959

1. On the Content and Value of Trace Elements in Urban Refuse Compost

by Dr. F. C. Gerretsen, Laboratorium für Mikrobiologie der Reichsuniversität, Groningen (Netherlands).

Although urban refuse compost is chiefly valued for its organic matter content, it also contains numerous trace elements indispensable for normal plant growth. A single application of the compost may be valuable for years afterwards, especially in soils which are deficient in one or more trace elements or possessing them in a form not assimilable by plants.

Numerous investigations have been conducted during the past decade concerning the importance of trace elements for plant growth. It has been shown that the trace elements are indispensable components of most of the enzymes. Manganese, for example, was found to be a component part of at least 13 enzymes. Although it could frequently be replaced entirely, or in part, by another element, such as magnesium, there are still uses in which it exerts a specific action. An example was shown by the author in the case of CO_2-assimilation.

Boron has special significance for those parts of the plant in which intensive cell division occurs, such as the growing points of higher plants which become stunted or even decay due to lack of boron. One can observe this in the case of sugar-beet heart-rot. Boron is also essential for nodule formation on the roots of legumes and for the nitrogen-fixation by Azotobacter.

Higher plants do not grow without copper and wheat, oats, peas, and beets (carrots) require more copper than such plants as buckwheat and serradella (European legume). The so-called "cultivation disease" (Urbarmachungskrankheit) is found not only on newly cultivated heath soils but also in older humus-rich sandy soils in which copper is in insoluble combination, difficult to assimilate. It has been shown repeatedly in the Netherlands that a copper deficiency can occur without characteristic external evidence accompanying it. In such cases application of copper sulfate or urban refuse compost results in considerable yield increases.

One element, the importance of which was only recognized in recent years (by investigations of E. G. Mulder among others), is molybdenum. Molybdenum deficiency occurs much more frequently than generally suspected, particularly in red soils rich in iron along rivers and creeks. Cauliflower and sugar-beets are particularly sensitive to this deficiency. Molybdenum is important in the plants assimilation of nitrogen from nitrates and in the enzymatic reduction to ammonia as the first step in protein formation. The element is also indispensable in the fixation of atmospheric nitrogen into bacterial proteins by means of Azotobacter and other N-fixing bacteria.

Zinc is another trace element of recently greater interest to science. A difficulty in studying zinc deficiency is that chemicals and laboratory vessels are all normally contaminated with zinc and very strict precautions must be taken. Zinc is an indispensable trace element for legumes, grains, onions, and other plants, particularly horticultural plants. Zinc deficiency is not rare in orchards of the Netherlands and the success one

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achieves by spraying or injecting a zinc solution into the trunk is sometimes surprising, not only in appearance of the leaves, but also on the yield. The great success with the use of one application of VAM compost in a few orchards in Wijster, resulting in 15% greater yields than plots receiving only fertilization, is likewise ascribed in part to the addition of trace elements. Deficiency in zinc has been found to inhibit the formation of auxins (growth substances) and of chlorophyl. The term "zinc-yellow disease" (zinkgelbsucht) has been coined.

Our laboratory determines the various trace elements, in soils and plant materials, by the so-called *aspergillus* method, although chemical analyses, particularly with the aid of complex ions (Komplexonen), has made recent progress. The mycelial weight of the fungus *aspergillus* is closely related to the amount of magnesium, zinc, molybdenum, iron, and manganese contained in the nutrient medium. Spore color varies from black through brown to yellow and white, according to the copper content. Trace elements in inconceivably small amounts can be detected by this method. Limits of anlayses are 0.2 to 15 millionths of a gram for copper, and about 0.001 millionths of a gram for molybdenum! The greatest difficulty lies, however, not in the determination as such, since this consists only of drying and weighing the 4-day old mycelial grown in the medium, but in complete exclusion of trace elements in the medium and vessels.

Table I shows the content of the most important trace elements and magnesium (not considered a trace element).

Table I

Content of Trace Elements and Magnesium in VAM Refuse Compost.

Element	% (dry weight)	Element	% (dry weight)
Copper	0.01-0.06	Boron	0.005-0.007
Manganese	0.002-0.03	Molybdenum	± 0.001
Zinc	0.007-0.023	Magnesium (as MgO)	0.11-0.34

These amounts always vary in summer or winter compost. In the following pictures, examples of a few analyses of some trace elements by means of the *aspergillus* method are illustrated. The experiments were conducted with town refuse compost from the Schiedam rasping plant.

Figure 1 shows, on the left, an Erlenmeyer flask with nutrient medium from which all trace elements have been removed. In the center the nutrient medium contains optimum amounts of trace elements. On the right one gram of compost has been added to the medium without trace elements. It is clearly perceptible that this amount of compost contains all the necessary trace elements that are necessary for optimum growth of *aspergillus niger* (Cu, Zn, Fe, Mn, Mo, and also Mg). The culture with the compost is even better-developed than that with the synthetic complete medium which perhaps indicates that even more elements exist in the compost not considered by us, e.g. gallium.

Figure 2 illustrates a magnesium determination; left: without Mg, center:

with 1 mg. of magnesium as $MgSO_4$, right: without Mg but with 1 gram of compost. Here, too, growth is best in the flask with compost.

In determining molybdenum in compost, a few pot trials (5 kg. of soil per pot) were conducted. Cauliflower was used as the trial plant in the first experiment, as it is known to be especially sensitive to molybdenum deficiency (see Figure 3). The seeds were sown in soil poor in molybdenum and seedlings died within a short time as seen in Figure 3 on the right. In the center, 200 grams of compost was added to the soil. The plants developed a little better but also soon withered. The pot on the left contains 400 grams of compost and here the plants have made somewhat better growth, even forming a small cauliflower, but the quantity of molybdenum was still insufficient to produce normal growth.

A similar experiment was made with turnips as trial plants. They also react sharply to molybdenum deficiency, but do not die as quickly. Figure 4 shows center: a pot without Mo but otherwise fertilized, left: a pot containing 10 mg. of ammonium molybdate, and right: a pot without Mo but with 200 grams of Schiedam compost. The vast differences in growth is nearly directly proportionate to amount of molybdenum as shown in Table II.

Table II

Pot Trials with VAM Compost in Molybdenum-poor Soils.

Pot No.	Compost per 5 kg. of Soil (gm)	Ammonium Molybdate per pot (mg)	pH at end of Trial	Yield (gm/pot)	
				Wet Wt.	Dry Wt.
493	---	--	5.26	15	1
494	---	--	5.12	17	2
490	---	--	5.15	8	1
487	---	--	5.30	14.5	2
426	---	10	5.49	359	57
427	---	10	5.45	389	56
497	100	--	5.60	395	50
489	100	--	5.51	418	53
488	200	--	5.63	400	60
495	200	--	5.49	398	54
491	400	--	5.93	407	58
486	400	--	5.79	480	67

Basic fertilizer per pot with 5 kg. soil: 3.5 g. NH_4NO_3; 2.0 g. K_2HPO_4; 1.0 g. $MgSO_4$; 0.1 g. $CuSO_4$.

It is thus shown that 100 g. of compost per pot achieves the same yield as with 10 mg. of molybdate, while greater amounts of compost increase the yield only slightly. The difference in pH between pots 426-427 without compost and 497-489 with 100 g. of compost are too small to cause significant mobilization of soil-molybdenum, and is therefore not responsible for the large yield increase.

An application of 100 gm. compost per 5 kg. soil corresponds to about

40 (metric) tons per hectare (18.1 T/acre), with a crumbly soil (depth) of 20 cm. Such a compost application is often used on sandy soils and contains an average of about: 60 kg. of Cu, 90 kg. of Mg. (as MgO), 0.4 kg. of Mo, 2 kg. of B, and 6 kg. of Zn (per hectare). These amounts vary greatly in winter and summer compost.

In any case, it is shown that compost is not only a valuable organic manure but also, by containing many, readily assimilable trace elements, can supply plants with inorganic nutrients, resulting in increased yields in many cases, even where no trace element deficiency is suspected. More recent investigations have shown that various plants with inadequate Cu, Mn, Zn, or Mo for optional growth, yet show no typical symptoms of deficiency, such as white leaf tips, leaf spots, chlorosis, etc., respond to treatment with proper trace elements by considerably increased yields. Compost application , however, produces great advantage in that a single application provides a whole series of available trace elements without risking yield reductions by trace element deficiencies.

2. Comments on the Construction of Grinders for Urban Refuse by Dr. E. E. Pfeiffer, Biochemical Research Laboratory, Spring Valley, Pennsylvania.

Hammermills for grinding urban refuse are severely tested by two factors: (a) by the irregular sizes and shapes of raw refuse materials, as well as irregularity of feeding rate; (b) by the quality of the materials. The mixing of organic and inorganic components forms a sticky, yet abrasive, mass which quickly wears out the hammers. This effect is increased by the build-up of the abrasive mass in the mill.

Measures to overcome these difficulties under (a) and (b). Regarding (a): The mill must be oversized. Under no circumstance should the desired average capacity only be used as the basis for selection of a mill. According to our experience with numerous makes, it would be better every time to select the next largest mill and not the one having the (desired) yield as stated by the manufacturers. The power requirement is also larger and should be the upper value of horsepower stated and admitted by the manufacturers. If the mill is rated 50 HP, it is probably better to choose 75 HP; instead of 75 HP, use initially 100 HP, etc. These factors should be considered, initially, in planning new plants. Of course the torque can be improved by a larger flywheel, but there are certain limits to this. In any case the flywheel should be generously sized, as it will be advantageous in case of sudden overloads.

Feeding the mill: Charging the mill should be done as uniformly as possible. If the refuse is shoveled onto the conveyor belt by workmen, they must be so instructed. With fully automatic conveyors, it is best to install an automatic circuit breaker in the line to the mill which immediately stops the conveyor belt in case of an overload. If we assume that the current flow at normal output is 120 amperes, then the cut-off shoud occur at about 150 amperes, even if the mill would still run at a current flow up to 180 amperes without the action of a circuit-breaker. In other words, a 30% overload of the rated current flow is permissible, a 50% (overload) is the highest absolute limit.

The mill hopper must be large enough to admit coarse and bulky pieces. The hopper sides purposely have no sloping, but only perpendicular, walls. Incoming material at best falls in a free drop into the mill. Thus, the same curve is formed as when one allows water to flow over the conveyor belt. The end of the conveyor should project somewhat beyond the brink of the intake opening.

In all conveying problems with urban refuse, coarse and pulverized, it must be considered that it does not "flow", frequently (it) does not even glide, on the contrary (it) easily forms bridges. When the intake opening is clogged, the hammers can be moved from beneath it; the clogging material forms bridges and does not move any farther. Many manufacturers have helped by building into the hopper a vibrating jointed plate (chain). This only makes the construction more complicated and is not necessary with an appropriately-sized opening.

The width of intake should correspond to the width of conveyor belt. A narrowing is very disadvantageous. The height of the intake hopper should consequently be kept as low as possible. Material should not accumulate therein. Perhaps pieces thrown out of it could be suitable trapped by a baffle. The inlet hopper must be easily accessible for cleaning. Thus, the throat should be dismountable by a pair of handles. It is therefore best not bolted but attached with pins. As the hopper is not mechanically involved, sheet steel with reinforcing frame is sufficient.

Regarding (b): measures to avoid the clogging action. Above all else care must be taken to prevent build-up of a sticky abrasive mass. Theoretically, the material to be ground should leave the mill after the striking and should not be further pounded by the hammers. This requires that all intervening spaces, above all between the hammer periphery and mill frame, be not too large.

The grates below the mill must permit the material to pass through immediately. The grid spaces must be sized so as to make this possible. This is the critical point missed by most of the mills. The grid spaces are graduated -- first smaller, later larger. Opposite the ends of the radii it is convenient to choose a larger opening in order to let refuse material still present pass through. If this mass is too coarse, it has to be picked up and brought back for regrinding by a second conveyor. Many plants accomplish this by using two grinders -- one under the other. The first for coarse, the second for finer, grinding. This method is probably more costly (requiring two mills) but is significantly easier on the grinders. For outputs up to 10 tons per hour one suitable mill is adequate; for outputs of 10 or more tons, we recommend double grinding because power requirements of a single mill would be too high.

Hammers: The distance from hammers to breaker plates is optimum at 5 mm, with an upper limit of 10 mm. The breaker plate is less prone to wear out than the hammers and is best made from tough manganese or chrome-nickel-steel. The plate-to-hammer distance should be maintained constant, requiring that breaker plates be adjustable according to hammer wear. Hammers should not be allowed to wear down 10 to 20 mm and only then adjust plates or build up hammers. Increased distance only encourages build-up of the sticky mass -- a common error. A quick means of adjusting breaker plates should be provided, such as in the Williams mill. Of course this has meaning only if the plates are actually adjusted!

To assist in avoiding sticky accumulations, the hammers should project only slightly beyond the discs between them. Short hammers are more efficient. They should be relatively heavy in order to have sufficient striking power. Hammer speeds are best at 1700-1800 rpm for smaller and 1300-1500 for larger mills. The same mill at 1750 rpm grinds at least half more and becomes clogged less than at 1350 rpm. If the mill must be direct-coupled to a 50 cycle line, instead of 60 cycle, so that only 1350 instead of 1750 rpm are achieved, a heavier mill is needed or a special drive must be installed. Smaller mills must run faster.

Selection of hammers: There are many observations concerning the steel in hammers. Manganese steel wears out relatively quickly. Chrome-nickel-manganese steel is better. Boron-carbon steel is, of course, more costly but has proved to be the best. The usual chrome-nickel steel hammers wear out, say, after 1,000 rounds, while the boron-carbon steel hammers last 3,500 rounds. The cutting edges, not the mass, of the hammers are important here. The cutting edge is best at 2-3 cm. thickness and tempered, not to brittle-hardness but to tough-hardness.

Worn cutting edges are rewelded. This is considered troublesome, costly, and time-consuming, but it is not if the appropriate welding electrodes and current are available. As about 2-3 cm. must be built up, only electrodes having corresponding diameter should be considered. The material must be applied at 120-140 amperes. To work with small electrodes at 30-40 amperes, requires as many hours as the other method does minutes! If amperage is inadequate, a motor-generator must be used.

Welded material must be tempered -- hammer welding is thus a workshop job. It is recommended that a second set of hammers be available. Changing hammers is simple to perform in all suitable mills and requires 40-60 minutes. In a new installation attention should be paid to make the changing as simple as possible. Hammers must be precisely balanced to avoid vibrations or irregular revolution. They must, therefore, be tested after each welding and be built up to the proper weight. A good welder and suitable equipment are necessary for frictionless operation of a refuse hammermill. They will probably save much vexation and expense.

Accessibility of the mill: The mill is opened about weekly to change hammers, every day or two for adjustment, and daily for cleaning. The interior must be easily accessible. Most mills are not. The upper hood is best fastened with hinges and provided with a pulley, that is permanently mounted. As the hood is not mechanically involved, a simple wedge closure, so that only the wedges need only be knocked out and the hood swung back with the pulley. Accessibility from the side and bottom is also necessary. None of the manufacturers have yet solved this.

Urban refuse contains all possible components that adhere, cling and cleave to the grids of the grate. Bits of clothing, stockings, especially nylon, neckties, strings, and leather belts are troublesome. To remove them the mill must be stopped before it clogs -- necessarily once a day, frequently more often. Frequent crawling under the mill to remove rags from below is too time-consuming. The simplest construction is for the lower half of the sides to be removable just as the hood, with a pair of handles. Cleaning tools are: heavy hooks on sufficiently long handles, a pair of prehensible pincers, and a scraper. Material stuck fast is knocked or even burned off. Once daily cleaning for small mills and twice daily for large mills should suffice. It depends on the type of refuse.

Mill damage is greatest with a mixture of ashes, dirty dust, and green plant wastes. This mixture produces a sticky abrasive mass which "cements" with pressure and heat. Ashes should be sifted out beforehand, light dust drawn off, with plant facilities for these purposes.

The grates: The design of grates beneath the mill appears to be the least adequate in present-day mills. If no grate is provided, the mill runs without hindrance but the pieces are relatively large, particularly of paper, textiles, and fibrous components. With coarse bulky material and a large proportion of inorganics, a coarse break-up without sieves may be provided. With material more favorable to composting and fewer ashes, the main mill with grating suffices. Grates should not be perforated steel plates but removable iron rods like boiler grids. Spacing is most important. Small spacing gives a fine grind but frequent clogging; wide spacing gives an insufficient grinding. Spacing must be adjusted to the incoming wastes. We recommend standardized grid rods with removable intermediate pieces so that the distances between rods can be altered. If rod supports are welded, intermediate pieces and rods can be simply shoved over them and these pieces should be on hand in different thicknesses to permit rod spacing adjustments.

Enlargement of rod spacing in the direction of rotation is practical. The smallest spacing is next to the breaker plate, the largest is on the opposite side. For example: spacing between 1st, 2nd, and 3rd grid rods -- 5 mm; between 4th, 5th, and 6th -- 10 mm; 7th, 8th, and 9th -- 15 mm; finally -- 20-25 mm. One should investigate patent rights so as to avoid infringement on this score. With material difficultly ground, one may sometimes dispense with the last third of the grid rods. This will result in both coarse and fine-ground material. They may be separated by a shield with return of coarse-ground material to the intake, or two grinds may be composted together.

Dead Space in the mill: Distances between hammers and mill housing are sufficient to pass the desired hourly output but not to allow for accumulations to pack and "cement". Iron pieces are not considered here as they can completely fill and choke a mill in a few minutes. Backsliding of the ground material through 180° or more, measured from the breaker plate, should be avoided. A trouble-free mill will discharge this material after a 180° turn. This can be corrected by grid rod adjustment.

Volume reduction: Our experience shows the volume of refuse to be reduced to about a fourth or a fifth by favorable milling action. The dead space should not be too large or it will become clogged and reduce output. But too small a space reduces the hourly output. Free passage of ground material is desirable.

3. The Refuse Typhoon, a Mobile Processing Plant by E. O. Reidel (Düsseldorf).

Development of an economically practical solution for the elimination or disposal of the "dry rivers" of refuse of large cities should be a primary objective. Nearly every problem in the processing method can be solved by means of our highly developed technics. The question is only whether the technical installation pays for itself and the product is sold at a realistic price.

The average attainable price of an urban refuse compost of 8 German marks per ton severely limits the costs of plant installation and processing. Most processes now used or available are eliminated if they cannot operate without subsidies. This is especially true for all processes requiring scanning of incoming refuse, repeated material handling before reaching marketable condition, and heating, forced aeration, or even microbial additives during the stages of the process. Many authorities believe that all necessary microorganisms exist in normal urban refuse, especially if it is ground and mixed with sludge. The materials need only be loosely stacked to provide for the desired decomposition. Certain automation is then necessary to maintain proper conditions. These provisions are provided in the procedure described.

The mobile unit, called a refuse "typhoon" provides for: magnetic separation, sieving to remove ashes and powdery wastes, and grinding. Figure 1 is a drawing of the portable unit with the following parts labelled: (1) pick-up apparatus, (2) magnetic pulley, (3) sieve, (4) grinder (Novorotor), (5) ferrous metal container, (6) chute for fine wastes, (7) discharge conveyor (ground material), and (8) diesel motor-generator with accessories. The spiral gatherer collects material to the center where a bucket conveyor (1) elevates it to a belt conveyor which further elevates it. The upper pulley of the belt is a permanent magnet (2). The sieve (3) (appears to be a spring-mounted vibrating screen) discharges fines directly beneath to a chute (6). The iron pieces fall beneath the magnet into a hopper (5). Toilings from the screen are discharged to the Novorotor (4), a double-acting hammermill. This mill provides milling action for hard components, tearing action for soft matter by means of two opposing rotors with hammers. The motor-generator (8) provides power. Discharge of ground material, to which fertilizer may be added at the mill, is by means of cross horizontal and elevating conveyors (7). (The entire unit is on one frame supported by four dual wheels and with a tractor connection on the generator end for pushing).

Figure 2 is a drawing showing two windrows (one of fines and one of ground refuse) being laid down by the machine as it is pushed through raw refuse windrows by an agricultural tractor. Labelled parts are: (1) pick-up apparatus, (5) ferrous metal container, (9) raw refuse, and (A-B-C-D) a discharged windrow.

The normal capacity of the refuse typhoon is 12 to 15 metric tons of refuse per hour. Assuming 13 tons/hour and a 75% efficiency, the plant will process 19,500 tons/year. Assuming 75% becomes compost at a value of 7 German marks per ton (about $1.67), an income of 102,400 marks would be realized. Expenditures would consist of:

	Marks
(a) Interest and depreciation (5-yr. basis)	38,000
(b) Diesel oil	25,000
(c) Transportation (2900 km.)	2,900
(d) Insurance	1,200
(e) Two laborers	24,000
(f) Spare parts and miscellaneous	9,900
Total expenses/year -	101,000

Ferrous metals are conservatively estimated at 2%, or 520 tons, and will be worth 15,600 German marks at a conservative value of 30 marks per ton. Thus, with an income of 118,000 German marks and expenditures of 101,000 marks, a balance of 14,600 marks or 8.75% of the capital cost of the plant (165,000) would be realized.

The versatile refuse typhoon is intended for small and medium-sized communities. It provides for iron removal, grinding, and windrowing for composting. A smaller unit will process 5 to 6 tons per hour and costs only 80,000 German marks. Operating costs of this machine are considerably less than one-third the above so that a sale price for the compost of only 4 marks/ton need be realized.

Processing must be synchronized with the storage and collection. Ground water pollution can be avoided by conducting operations on hard-packed ground or prefabricated concrete slabs. For the one to three turnings of the ground refuse, there is a special apparatus worth its price of 6,000 to 11,000 German marks, the Jabelmann-Gerät und Wurf-Transporteur. Operating costs are about 0.30 to 0.50 German marks per ton. Low hauling costs for the refuse, because of the mobility of the plant, are considered in the computations. No plant building is needed for the refuse typhoon.

4. Abstracts of Technical Papers received at the Secretariat.

a. Peyer, E. - Trials in Erosion Prevention in Vineyards and Their Evaluation. Schweiz. Zeitschrift für Obst-und Weinbau, 67(24)-1958.

Summary: Extensive experiments have been conducted since 1955 with the collaboration of the two research institutes at Wädenswil and Zürich-Oerlikon and the Eidg. Anstalt für Wasserversorgung, Abwasserreinigung und Gewässerschutz (EAWAG). These should indicate the possibilities of use of refuse composts in viniculture. Prevention of erosion damage by treatment of vineyard soil with compost is of primary interest. The author reports on the first years of the trials which have turned out extraordinarily favorably. Not only was the erosion of fine soil reduced to a minimum but the friability of the vineyard soil was also considerably improved by compost treatment.

b. Gisiger, L. - Composting City Refuse and Standards of Use. Schweiz. Landwirtschaftliche Monatshefte, Nov. 1958.

Summary: Various sanitary methods of refuse disposal have been thoroughly tested in large-scale experiments in recent years. Emphasis has been placed on improved incinerators and the manufacture and use of compost. Difficulties of composting have been eliminated by well-conceived mechanization of the processing of refuse by the introduction of vibrating screens, electromagnets, and hammermills. Favorable results have been obtained in composting digested or fresh sludge with refuse and the problems of composting today have been solved. While incineration is purely an economic problem, composting touches upon the interests of agriculture, viniculture, and forestry. Uses of refuse and compost may be summarized as follows:

1. Sorted and pulverized fresh refuse may be used to advantage in preparation of hotbeds as a substitute for horse manure.

2. Compost, in large amounts, has been added to slightly acid soils at forestry planting schools with good success.

3. With high applications required for compost there is danger of overliming and adding excessive boron in general agriculture and, particularly, in horticulture. Therefore, in processing compost, attention must be given to removal of basic materials (such as ashes) and also to screening out glass particles because of their boron content.

4. The composting plant must be able to deliver compost to the farmers in the fields.

5. A very favorable price might be paid for compost today by gardeners, forestry schools, and horticulturists, but only a very modest price can be considered economical in agriculture. Based on the nutrient content each 100 kg. of compost might sell for 0.70 to 1.00 Swiss francs, including transportation and distribution. Thus, the compost must be fixed at 0.20 to 0.30 francs at the plant, or 0.40 to 0.70 francs piled in heaps. It should be remembered that the use of compost in agriculture is made in late fall to spring, during the non-growing season.

c. Braun, R. and Allenspach, H. - Experiments in Composting Refuse and Sludge. Schweiz. Zeitschrift für Hydrologie, 20(1)-1958.

Summary: (a) Sewage Sludge addition: Investigations indicate it is possible to add to refuse equal amounts of settled sludge from a primary or complete sewage treatment plant when using the Dano biostabilizer composter, provided that the sludge moisture content is reduced to 70-75%. These experiments were based on using summer refuse. It is assumed that, with the drier winter refuse, the amount of sludge added could be further increased. To what extent refuse-sludge mixtures could be composted other than in the biostabilizer must be determined by additional experiments. The tests were conducted at the Dano plant at Rüschlikon (Zürich Canton, Switzerland). It is also possible to mix unthickened digested sludge in biostabilizers, but in amounts considerably less than from equivalent populations.

In principle, raw concentrated sludge can also be used with refuse in biostabilizers without sludge odor problems, but only in less than equivalent amounts of refuse. Trouble may arise in Dano units due to the lipids content of sludges because fresh sludges have reduced liquid-holding capacity.

(b) Windrow composting: Ordinary humus soils have proved most favorable for windrow composting. Somewhat less favorable was a gravel-packed base, while a perforated concrete slab with air ducts beneath gave poor results. As the composting area must include roadways, the authors recommend a compromise solution with use of gravel base. Trapezoidal piles 1.5 meters high have proved good. Worthy of recommendation is the covering of fresh windrows with a thin layer of compost.

(c) Improvement of compost quality: Refuse-sludge compost contains twice as much organic material and 50% more alkali-soluble humus substances than the usual refuse compost. The addition of sludge also improves the nutritional value of compost.

d. Meyer, J. H. - Some Practical Results with Refuse Compost in Vegetable Gardening. Schweiz. Garten-Blatt, 79(46)-1958.

Summary: In 1956 the author raised tomatoes, pumpkins, and cucumbers outdoors directly in a refuse compost pile 30-40 cm. high without any soil. Tomato growth was satisfactory but pumpkins, and especially cucumbers, showed the following initial injuries: plants became yellowish, formed only short internodes and very small leaves, and wilted slightly during hot afternoons but without burned leaf edges. After heavy rains, the plants again became green and showed somewhat better growth. Fruit set on normally but soon dropped off. These negative phenomena disappeared in time. Apparently the degree of decomposition (ripeness) of the compost was insufficient. Rhubarb was particularly suited to compost treatment, developing outstanding harvests even when planted in immature compost. The author recommends simultaneous application of a complete acidifying commercial fertilizer to guard against any nitrogen robbing by immature compost and the danger of over-alkalizing with plain compost.

e. Zurich Symposium-1955 - Present Problems in Refuse Disposal, Treatment, and Utilization. Publ. R. Oldenbourg, München, 174 pp. (28.40 German Marks)-1957.

Summary: This symposium on the processing, disposal, and utilization of urban refuse led to the foundation of IRGR. The articles appeared in French in the Schweiz. Zeitschrift für Hydrologie, 17(2)-1955 (Burkhauser Publ., Basel) and this is the German version.

Because of lack of space we shall include other reports received in the next Information Bulletin.

5. Discussion Corner: We again invite you to send brief contributions to the Secretariat, IRGR.

a. Naef, H. - Is the Refuse Typhoon Suitable for Swiss Conditions? (Discussion of article by E. O. Reidel, this Bulletin).

The author visualizes handling 20,000 metric tons of refuse in 250 working days (2,000 working hours) and selling the entire amount of compost and ferrous metal. This is processing 80 tons/day or 10 tons/hr. or 50 cu. m/hr. But how shall communities of 1,000 to 10,000 (700 to 7,000 cu. m/yr.) handle their refuse? (An elaborate theoretical table is presented showing quantities from these two population groups with 4,200 and 14,000 tons/yr. of refuse, respectively). Under these conditions, compost at 8 Swiss francs/ton, there must be provided 2.65 francs per ton just for three-fold turning of the compost. The discussor points out that only about 10 francs/ton could be realized from unbaled iron scrap. Yearly budgets for communities of 1,000 and 10,000 would be about 92,500 and 124,500 francs with incomes of only 26,040 and 86,800 francs, respectively -- resulting in net expenses for raw refuse treatment of 15.8 and 2.7 Swiss francs/ton. Use of a mobile plant to serve small Swiss communities is extremely irrational, and a fixed plant is economical for larger cities. Even the consideration of a smaller mobile unit (at half output) changes the analysis but little.

Comparison between a mobile refuse compost plant and a permanent plant serving 30,000, in five 5,000-population cities and five 1,000-population villages, shows (by another elaborate table of calculation) that there is very little difference in manhours worked in the two plants, while the fixed plant should have a much longer amortizing period. Resulting conclusions are subsidies of 12.7 francs vs. 13.2 francs/ton for mobile vs. fixed plants (amortization of mobile plant in 5 yrs., fixed plant in 15 yrs.).

The discussor concludes:

(1) The refuse typhoon continues open dumping of up to a week whereas the fixed plant processes refuse immediately.

(2) The estimated high output of the typhoon may be difficult to achieve because of the moving time whereas the permanent plant also works during the time the refuse is being transported.

(3) The typhoon apparently offers advantages in initial cost but roads and site preparation are more expensive and the men and equipment are continually exposed to the elements.

(4) The rotating pick-up of the typhoon might be rejected by men who know refuse and the relatively small conveyor belts may not handle large items of refuse. Operation of the typhoon without breakdowns or delays is inconceivable.

6. News Briefs.

a. Bangkok (Communication from Georges Dobrouchkess, Paris, French IRGR Representative).

A composting plant for the city of Bangkok (1 million) has been constructed to process refuse. It is said to be an odorless process. Non-compostables are removed by machine and by hand. The sorted refuse is then pulverized mixed with sludge, and decomposed aerobically in 6 to 8 weeks. Compost yield is estimated at 80,000 tons/yr. The plant was built by John Thomson Co., Ltd. (Wolverhampton, England). In the cities of southeast Asia, the refuse is considerably richer in decomposable organic matter than in Europe. About 95% of the refuse is compostable but this proportion is lower in extensively industrialized areas.

7. Information from the Secretariat.

a. English Edition of Information Bulletins: World-wide interest in the Information Bulletin continues. The five previous numbers have been sent in German and French versions to 30 nations. It has been our longtime desire to publish the Bulletins in English because of the interest from English-speaking individuals. An English edition has not been produced for financial reasons. Now the United States Department of Health, Education, and Welfare, Public Health Service, Savannah, Georgia has undertaken to translate and distribute the Information Bulletins to interested English-speaking persons.

b. International Congress on Disposal and Utilization of Town Refuse: An international conference will be held at Scheveningen, the Netherlands, April 27 - May 1, 1959, sponsored by IRGR, Stichting Compost (Amsterdam), and the International Agricultural Center, Wageningen, the Netherlands. Subjects will include results of various European research and experimental work in practical operations, compost evaluation, and compost utilization. Inspections to the most important Dutch refuse disposal plants are included in the agenda.

The Netherlands is the classical land of refuse utilization. Urban refuse has been processed into compost and the compost successfully applied in forestry and agriculture for decades. The practical experiences and results of Dutch experts should provide leadership for workers in other countries.

Provisional Program:

(1) Development and significance of refuse processing in The Netherlands.
(2) Techniques of processing refuse (new developments and special technical problems).
(3) Compost evaluation (biological processes in the conversion of community refuse and the influence of humus on the assimilation of mineral substances by the plants).
(4) Compost utilization (long-term effects of refuse compost and utilization of compost in sub-tropical lands).
(5) Sufficient discussion time is allotted after each paper. Papers and discussions will be delivered simultaneously in English, French, and German.

Inspection tours include:

(1) Rasping plant at Delft or Schiedam (choice).
(2) Dano plant at Soest-Baarn.
(3) Van Maanen system (large-scale operation) at Mierlo, near Eindhoven.

The first two excursions will be made in the afternoons, following morning sessions; the last excursion will be held on Friday, May 1 and participants may depart from Eindhoven. In the tours are included visits to Keukenhof flower gardens, blooming tulip and narcissi fields, and a boat trip through canals of Amsterdam. Additional excursions are being organized for the ladies.

Registration fee is 70 Guilders per member, hotel and meals extra.

8. Reprints Available from the Secretariat:

Teensma, B. Erfahrungen über die Anwendung von Stadtmüllkompost in den Niederlanden. (Experiences in the Utilization of Urban Refuse Compost in the Netherlands). Address at AkA meeting, Düsseldorf, Vortrag AkA-Tagung Düsseldorf, VKF-Mitteilungen Heft (13) 72-78, 1957.

Horstmann, O. Erfahrungen mit der Kompostanlage Heidelberg. (Experiences at the Composting Plant at Heidelberg). VKF-Mitteilungen (14) 36-40, 1957.

Rohde, G. Die Kompostierung von Schweinekot. (Composting Pig Manure). "Mitschurin-Bewegung" (24)-1956.

Steigerwald, E., and Springer, U. Weitere Versuche mit Müll, Müllkompost und Müll-Klärschlamm-Komposten 1950-1952. (Further trials with refuse, refuse compost and refuse-sludge composts). Zeitschrift für Pflanzenbau und Pflanzenschutz 4(5), 1953.

Steigerwald, E. Müll-Klärschlamm-Kompost zur Verbesserung und Düngung des Bodens. (Refuse-sludge compost for improvement and fertilization of soils). Mitteilung der Acker- und Pflanzenbauabteilung der Deutschen Landwirtschafts-Gesellschaft, Frankfurt a.M. 1956.

Ministry of Agriculture, Viniculture and Forestry, Rheinland-Pfalz District. Kompostierung von Müll und Klärschlamm. (Composting of Refuse and Sludge)-1956.

Stahlschmidt, V. Entwicklung der Dano-Stabilisator-Methode zur Kompostierung von Müll und Klärschlamm. (Development of the Dano Biostabilizer Method of Composting Refuse and Sludge). Städtehygiene (12), 1956.

Straub, H. Das Klär- und Kompostwerk der Stadt Baden-Baden. (The sewage treatment and composting plant of Baden-Baden). Gas- und Wasserfach 92(24) (Wasser), 1951.

Allenspach, H. Untersuchungen über die gemeinsame Aufbereitung von Klärschlamm und Kehricht. (Investigations on composting mixed sludge and street sweepings). "Plan" (3), 1956.

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Straub, H. Kompostierung städtischer Abfallstoffe - Erfahrungsbericht vom Kompostwerk Baden-Baden. (Composting city refuse - Report of results at the Baden-Baden plant). Gesundheitsingenieur, 77(19/20), 1956.

Straub, H. Herstellung von Kompost aus Abwasserschlamm und Hausmüll. (Making compost from sewage sludge and domestic refuse). Berichte der Abwassertechnischen Vereinigung e.V. (1), 1949.

Hörler, A. Zur Frage der Zulassung von Küchenkehrichtzerkleinerungsapparaten (Küchenmühlen). (On the question of approving kitchen garbage grinders). Schweiz. Zeitschr. fur Hydrologie, 17(2), 1955.

IRGR. Informationsblätter. (Information Bulletins) No. 1-5 in German and French.

Jaag, O. Aktuelle Probleme der Müllkompostierung. (Present problems in refuse composting). Vortrag VI. Internationaler Kongress für Städtereinigung in Frankfurt a.M., October 15-18, 1957.

De Groote, R. Analyse und Beurteilung der Qualität von Stadtmüllkompost. (Analysis and evaluation of the quality of urban refuse compost). Reprint from the Vortragsheft der Arbeitstagung der Arbeitsgemeinschaft für kommunale Abfallwirtschaft (AkA), Düsseldorf, July 4-6, 1957 (Price: 12 Swiss francs).

Jaag, O., Walker, H., Allenspach, H. and Braun, R. Müllverwertung. (Refuse Disposal). Reprint from the Neuen Zürcher Zeitung, technical supp. June 18, 1958.

Buck, K. Herstellung von Müllkomposten und Müll-Klärschlamm-Komposten und Prüfung ihres Düngewertes. (Preparation of refuse and refuse- sludge composts and testing their fertilizer value). Reprint from Zeitschrift für Acker- und Pflanzenbau, 105(4), 1958 (Price: 1.20 Swiss francs).

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INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)

Information Bulletin No. 7

July 1959

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Report on the First International Congress on Disposal and Utilization of Town Refuse, Scheveningen, the Netherlands, April 27 - May 1, 1959, sponsored by IRGR with collaboration of the Compost Foundation (Stichting "Compost"), Amsterdam; organized by the International Agricultural Centre, Wageningen, the Netherlands.

Dr. O. Jaag, President of IRGR, Zürich, was Chairman of the Congress which was attended by approximately 200 participants from the following nations: Belgium, Denmark, England, Finland, France, Ireland, Iceland, Israel, Italy, Japan, Yugoslavia, the Netherlands, Austria, East Germany, Poland, Portugal, Sweden, Switzerland, Spain, Czechoslovakia, United States of America, West Germany. Representatives of the World Health Organization also participated.

Through papers, discussions and visits, participants obtained a comprehensive picture of the present status of municipal refuse composting. Problems were discussed concerning the processing of refuse and its utilization in agriculture, horticulture, and viniculture. Participants had opportunity to visit the following composting plants: Soest-Baarn (Dano process), Delft and Schiedam (rasping system), and Mierlo (van Maanen system). A round-trip through the Netherlands was organized (May 1-6) during which visits were made to compost plants at Wijster (van Maanen system), Almelo and Hengelo (rasping system), Enschede (Dano process), and Dantumadeel (hammermill).

The purpose of the Congress was to show the scientific bases for the biochemical changes during composting. It was shown that in aerobic decomposition pathogenic bacteria, worm eggs, and weed seeds can be destroyed. This is caused not only by temperature rise during decomposition but also by production of antibiotic substances by the decomposing organisms. A sanitary compost is assured at temperatures of 50 to 60°C. It should be the aim to adapt composting development to the latest scientific information with less emphasis on the problem of pre-treatment of the raw materials and more on suitable performance and guidance of the composting process. It should then be possible to obtain a valuable product even with a short decomposition period.

An important problem is the concomitant processing with sewage sludge. It has been demonstrated that composting of refuse and sludge not only solves the difficult problem of sludge disposal but also considerably increases the quality of the compost. Recently developed plant physiological and microbiological test procedures have been used in addition to the classical methods of evaluating compost quality such as chemical analysis and pot and field trials.

Compost use has not only instantaneous but also long-term effects. It therefore is a valuable supplement to mineral fertilization as it improves soil structure and biological activity, the fixing of nutrient materials in soil, the nutrient intake of plants, and the water- and air-retention balance of the soil and thus can cause a yield increase.

Refuse-sludge composting has proved to be a sanitary, economically practical, and agriculturally valuable procedure for utilization and disposal of urban wastes. The Congress has shown that these problems occur in all nations and must be solved through international collaboration and exchange of experiences, which is also the aim of IRGR.

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1. Development and Significance of Compost Preparation in the Netherlands

by Engineer A. W. van de Plassche, Director General, Ministry of Agriculture, the Hague, the Netherlands.

The interest in converting urban refuse to compost has been very great in the Netherlands from time immemorial. There was a large demand for compost long before synthetic fertilizers came into use. Cities composted refuse by a simple process which enabled them to sell to farmers at a low price. This was especially true in the northern provinces where many reclamation projects were conducted on swampland with the aid of refuse compost.

A change occurred about 1890 when artificial fertilizers were introduced. Holland soon became one of the largest consumers of artificial fertilizer. Farmers became less and less interested in stable manure and compost because, with the help of easy-to-handle fertilizers, such outstanding success was achieved that prosperity was afforded even for the constantly increasing population. Declining interest in compost coupled with increasing demands for artificial fertilizers forced urban and rural communities to look for new ways of refuse disposal. Some solved this by dumping the refuse on wastelands or into natural basins. Rotterdam installed an incinerator in 1912, Amsterdam in 1918. Smaller cities continued use of refuse in agriculture. As it was not converted into usable compost, however, it found little approval, particularly regarding sanitation.

A new trend began in 1929 with the decision of the Hague to compost rather than burn its refuse. The government made capital available for the foundation and operation of the N. V. Vuilafvoer Maatschappij (V.A.M.) (Refuse Disposal Company). This financing enabled authorities to exert some influence on the otherwise independent company. The first plant designed by V.A.M. was for the Hague and was built at Drenthe in 1931 using a system developed by Engineer van Maanen. It is still operating and processes the refuse from about 650,000 people from the Hague and surrounding communities. Original compost sale price was very low but rose sharply after the war and now amounts to 3.75 guilders ($1.00) per long ton at the plant for agricultural use and 12 guilders ($3.20) for horticultural compost.

Agricultural research was heavily emphasized by the authorities after World War II. In 1945 the government began to make substantial subsidies available for agricultural research with chief attention paid to soil fertility, fertilization, structure, and trace elements. A great interest was thereby aroused in organic fertilizers, particularly refuse compost, as a counterbalance to the exclusive and increasing use of mineral fertilizers with the resultant depletion of soil organic matter. In 1950 the government appropriated 10 million guilders ($2.67 million) for the following specific purposes:

(1) Construction of a composting plant at Schiedam using the rasping system developed in Holland.

(2) Six million guilders ($1.6 million) for 20-year interest-free loans to municipalities for constructing and operating composting works. Eight cities have built plants to date, 3 Dano and 5 rasping system plants.

(3) Construction of a more modern plant of the van Maanen process at Mierlo in North Brabant Province.

The Compost Foundation (Stichting "Compost") was created with 1 million guilders ($267,000) available for applied research and dissemination of information to those interested in compost plant construction.

About 350,000 metric tons or 25 percent of the total of 1.3 million tons of urban refuse yearly discarded in the Netherlands is now processed into compost and used with good results in agriculture and horticulture. Approximately 40 percent of the plant output at Delft and Schiedam is fresh pulverized refuse used in hotbeds. The use of compost in mushroom growing is now being investigated and the recently-developed use as bedding material in chicken and pig raising shows good results. Composting refuse with stable manure saves the need for purchasing straw and is more beneficial than ordinary stable manure.

Closer collaboration between compost procedures and users will be necessary in the future. Compost production in many areas has sharply increased bringing danger to the supply and demand equilibrium. Excess production may be solved by wider distribution and the sharing of costs thereby entailed. Efforts must be made to keep the prices low enough so that farmers can buy it. Such collaboration would have the advantage of more favorable publicity for the use of compost without resulting in an excessive increase in expenses of the individual plants. The Government of the Netherlands is greatly interested in the further development of compost and follows this development with particular attention.

2. Recent Developments in the Technique of Refuse Processing by Prof. Dr. F. Pöpel, Techn. Hochschule, Stuttgart.

Municipal solid and liquid wastes can no longer be simply dumped into watercourses or pits for sanitary and aesthetic reasons. There therefore occurs, in thickly settled areas with intensive use of the soil, the necessity of returning as much waste as possible to the soil by appropriate preparation and utilization. Two accepted methods of treating urban wastes are incineration and composting.

Hygienic requirements are completely satisfied by burning municipal liquid and solid wastes. Recent technical developments have held operating costs of large incinerators to a tolerable level, assuming that all the energy produced during the entire year can be sold. Incinerator installations in smaller communities are very costly and here difficulties arise regarding sale of the energy. In addition, no substances are returned to nature by the burning process.

Composting of liquid and solid community wastes in suitable plants also fulfills the hygienic requirements. Composting plants are less expensive to build and operate than incinerators. They can moreover be built to any size requirements and are therefore well-suited to small communities. Operating costs can generally be covered by the sale of compost and salvaged materials. Farmers and market gardeners obtain valuable organic materials in compost for the improvement of soil structure and fertility.

Composting processes for refuse and refuse-sludge in common use today may be summarized as follows:

Composting raw or presorted, but not pulverized refuse in piles that are aerated many times until compost is mature with subsequent mechanical removal of shards and other nondecomposable debris (Indore, van Maanen, and Baden-Baden systems).

Preliminary composting of raw, presorted, or pulverized refuse in closed fermentation chambers by the Earp-Thomas, Dano, Beccari, Verdier, and Frazer-Eweson methods with subsequent further maturing of the compost in piles.

Mechanical pulverization of raw refuse with grinding sieves (Dorr-Oliver) or hammermills (Bühler, Hazemag) with subsequent decomposition in piles turned over many times until the compost is completely matured.

Insofar as the moisture content and control of the piles assures aerobic decomposition, all three methods can produce hygienically unobjectionable compost (regarding pathogens, weed seeds, worm eggs, etc.). If anaerobic conditions appear in the piles, odors, vermin, etc. cannot be evoided. Various procedures in these systems may now largely be mechanized, even automated. Some subordinate problems, such as recovery of salvage items other than iron, still require better technical solutions. The quality of compost requires that it be as free as possible from stones, glass fragments, etc. These shards are now either pulverized (hammermills, roller crushers) or removed (ballistic separators, rotary screens, sorting belts, gravity separators [secators]).

In the spring, market gardeners use large amounts of partially decomposed compost as filling for hotbeds. There are other regions where more and more raw compost is applied by preference in the autumn. Such seasonal demand has led to a search for methods of storing undecomposed compost without loss. Storage in compact piles leads to anaerobic decomposition with all its unfavorable accompanying phenomena. Briquetting, followed by air drying to residual moisture of 5 to 10% is a promising means of preserving immature compost. Compost briquettes can be easily transported and stored. As most decomposing organisms are sporogenic, it is only necessary to break up the briquettes in a small hammermill and dampen them to an optimal moisture content of 40-60% in order to obtain decomposition temperatures of up to 70°C.

General statements cannot be made about optimum prerequisites for rapid and unobjectionable composting although the individual factors in the decomposition process are very well known. The oxygen consumption, carbon dioxide production, and heat production of microorganisms are of great interest. Lack of suitable apparatus has probably prevented much study of the oxygen requirements during decomposition. Oxygen uptake studies at Stuttgart with refuse and refuse-sludge mixtures revealed requirements of the latter to be about twice as high (about 7.2 gm O_2/Kg dry weight/day) than for refuse alone (4.2 gm O_2). Purely (sic) matured compost requires only about 10% as much oxygen as raw refuse with an optimum moisture content.

For composting with refuse, sewage sludge has to be dewatered either naturally or mechanically; i.e. it can first be air-dried on beds and then piled for decomposition using the heat produced for drying to a solids content of 80-90%. The air-drying process can be accelerated by plowing up the drying beds several times and then piling the sludge into windrows for decomposition. Mechanical means of dewatering of sludge are:

Hot air drying
Filtration (vacuum or pressure filters)
Centrifuging
Vibrating thickening

The first two methods are too costly in operation. Filtrates contain almost exclusively dissolved substances and the efficiency is consequently considered good. The last two methods yield both colloidal and larger suspended solids in the effluent requiring further treatment on drying beds or sand filters. However, the operating costs are considerably lower and capacities far greater than for the first two methods.

Joint composting of sludge and refuse offers the following advantages:

> The aerobic thermophilic composting transforms the sludge to meet hygienic requirements, eliminating pathogens, weed seeds, and worm eggs.
>
> The quality of compost is improved by addition of sludge, particularly by increases in nitrogen and permanent humus contents.
>
> Sludge addition intensifies the composting by inoculation with microorganisms, reduction of C/N as a result of the high N content of sludge, and by moistening the refuse which alone is too dry.

3. Special Technical Problems in the Processing of Urban Refuse by Engineer S. A. Gothard, Consultant Engineer, Public Health Offices, South Hill, Jersey, C. I., England.

The transformation of urban refuse into compost differs from other industrial processes in that the raw materials cannot be selected so as to fit the desired end product, but must be taken and used as is. This circumstance creates special problems of a physical and biochemical nature.

This paper describes the various problems and their solutions with reference to the Jersey Waste Conversion Plant. It is located in a community wherein agriculture is pursued in a strictly limited area and there is also a flourishing tourist trade. These factors cause a great need for organic fertilizer while simultaneously necessitating careful attention to hygenic and aesthetic considerations. The Jersey compost plant must comply with the following:

> Production of good quality, sanitary compost from equivalent amounts of refuse and sludge.
>
> Operation as efficiently as possible on a small site.

Operation with minimum labor, maximum mechanization, automation where possible.

Avoidance of any kind of odor production because of proximity to settled areas.

The plant serves 57,000 residents with 100,000 persons at the peak of the tourist season. Plant capacity is 60 metric tons/day but it has treated up to 100 tons/day.

Raw refuse is freed of ashes and cinders in a rotary screen. The fine dust removed is stored for later use in the compost. Glass shards, nonferrous metals, and other noncompostables are removed by hand from a conveyor belt. Iron and tin cans are removed magnetically, baled and, together with other metals, sold as scrap. Remaining refuse is pulverized in a Dorr-Oliver rasping machine (refuse treator) then led to a ballistic separator which removes particles of glass, cinders, etc. Coarse refuse such as large cardboard boxes, bushes, and slaughterhouse wastes are ground in a hammermill. The ground materials from the two mills then pass over automatic scales where dust and sludge are added in the amounts desired. Materials are mixed in a (rotating) drum. Prepared material is then conveyed by a crane to the top of a tower containing six chambers, one above the other. Each day the refuse drops from one cell to the cell below, thus remaining in the tower a total of six days. In 2-3 temperatures of 50 to 75°C are developed. The prefermented compost is then allowed to mature in a covered area for 8-12 weeks.

With such varied material as refuse it is difficult to prevent accumulation of material at any point in the preparation process, particularly when processing is largely automatic and operated with a minimum of personnel. All units are therefore interlocked in series so that, in case of a breakdown of any one machine, all other machines "upstream" will also stop.

A special problem is the cinder and dust content of the refuse. Ashes are undesirable and are therefore removed in the rotary screen. Fine dust is valuable because of its organic content and trace elements; but the dust content in winter is so high that the quality of the compost is impaired. Yet there is practically no dust in the summer refuse and a certain amount is desirable, particularly as filler for the sludge. So dust is screened out, stored, and later mixed with the refuse again in the desired amounts.

A swing hammermill was first used to grind the raw refuse, but it showed two disadvantages in practice: rapid wear with consequent high maintenance costs, and lack of uniformity in the grind, with resulting chunks of pottery, shoe soles, etc. leading to consumer complaints. Therefore, the rasping (grinding) machine developed in Holland was specified and yielded an excellent product. Tree trimmings, cardboard cartons, and other coarse refuse were first ground in a hammermill before being fed to the rasper.

Preliminary trials indicated an optimum moisture content of 65% for composting. Thus the desirable proportions of dust and water or sludge were known and the only problem lay in the great variation of the amounts introduced with the refuse during the day. An automatic scale on the pulverized refuse conveyor belt which records the refuse input rate and controls the input of dust from storage solved the problem. A second scale on this belt records the input of dust and the two weighings, electrically integrated, regulate the speed of the sludge (or water) pump. These proportions desired, which are dependent on moisture content of the refuse, are set at a control board and automatically maintained regardless of varying refuse input.

The greatest problem is the adequate turning and aeration of the compost so that rapid and sufficient aerobic decomposition occurs. The 6-story tower was constructed after numerous trials with various systems. The floor of each cell consists of a number of perforated semi-circular troughs which can be rotated to dump their contents to the cell below. The material is stacked to a depth of about 4 feet in the uppermost cell and is dumped after 24 hours to the cell below. The capacity is 80 metric tons per day and total detention is 6 days so that 480 tons can be precomposted in the tower having a floor area of 1360 sq. ft. A chimney effect develops due to temperatures of 70-75°C in the tower so that artificial aeration is unnecessary.

Hazard may result if the compost is used immediately after discharge, so it is further ripened in windrows for 8-12 weeks. At maximum moisture content, a critical period of 6 weeks has been found when additional moisture causes anaerobic decomposition. Thus the Jersey plant provides 6 weeks of storage under shelter after removal from the tower. The compost is then piled outdoors. The shed floor is of hollow concrete blocks, the beneficial effect of these being seen in the almost immediate growth of fungi occurring at the bottom as well as the top of the windrows. Fungi are instrumental in the decomposition of paper. The C-N ratio (C/N) of Jersey refuse is very high because of the large proportion of paper and cardboard; consequently decomposition proceeds very slowly in plain refuse composting. With the addition of sewage sludge a definite speedup of decomposition can be achieved.

Periodic tests of the compost have shown complete absence of pathogens and it was additionally found at an agricultural research station that Jersey refuse-sludge compost helped check certain plant diseases, particularly didymella disease of tomatoes.

Following are some cost figures on the Jersey plant:

Mechanical equipment and composting tower	$311,000
Foundations, buildings, roads, services, etc.	286,000
	$597,000

Operating costs: About $50,400/year
Income: About $26,600/year

Yearly compost production amounts to about 8,000 metric tons but will be about 12,000 tons at full capacity without increasing operating costs.

4. Biological Processes in the Composting of Refuse by Prof. Dr. Hans Glathe, Director, Institutes für Landwirtschaftliche Mikrobiologie, Justus-von-Liebig Universität, Giessen, Germany.

A research group at the Giessen University was established to study the scientific and practical fundamentals of the composting of refuse and sludge from the points of view of agriculture, microbiology, and human and veterinary hygiene. Participating are Institut für Hygiene (Prof. Kemkes), Institut für Veterinärhygiene und Tierseuchen (Prof. Roots), Veterinär-parasitologische Institut (Prof. Oetzel), and this Institute.

If urban refuse and sludge are to be used, preliminary treatment is required to transform it into a substance for soil improvement and render it free of pathogenic organisms. Composting consists of the interaction of a great many individual processes difficult to regulate because of the variations in composition of the raw materials. These processes may be divided into two groups:

(1) Processes bringing about chemical, physical, and biological transformation of the organic matter.
(2) Processes that influence the fate of pathogens.

The only systems to be put into practice are those which result in a sanitary end-product. To date opinion has been that composting is sanitary if the temperature rises to 60-70°C. Golueke and Goteas supplied data on lethal temperatures for pathogens but the duration of the temperature is important. Also the antagonistic effect of fermentation bacteria upon the pathogens must be taken into account. It is believable that the high temperatures formerly recommended are not necessary due to a combination of reasonably high temperature and antibiotic activity (see report by Knoll). This would be advantageous because too high a temperature results in decreased decomposition rates.

These experiments were performed with refuse-sludge mixtures at the Baden-Baden composting plant. The field studies were performed by the Works Chief, Dr. Straub, and his co-workers. The composition of refuse-sludge compost at Baden-Baden is as follows:

	Range	Average
Moisture	25.9-43.0%	35.4%
Ash	44.7-64.8%	53.9%
Organic matter	8.4-12.5%	10.8%
Total nitrogen	0.2- 0.43%	0.34%
P_2O_5	0.25-0.40%	0.32%
K_2O	trace-0.29%	--
Ca CO_3	3.2 -6.8%	4.7%
Boron	22.6-70.0 ppm	39.0 ppm
Zinc	592-1280 ppm	826 ppm
Copper	86.7-157 ppm	125.6 ppm
Manganese	132-617 ppm	344 ppm

To overcome sources of error inherent in the heterogeneity of the refuse, bags containing carefully pulverized "model compost" were inserted in the compost windrows. Temperatures were measured with thermocouples which remained in the heaps. A pressure tube was placed close to the compost bags to enable gas analysis to be performed.

Miehe in 1930 showed that composting of hay is an exothermic process caused by microorganisms, as sterile hay did not heat up. Bacterial counts in the refuse-sludge mixture showed up to 6 billion organisms per gram. The true number must be considerably higher as only a fraction of the microorganisms can grow on the medium used on plates by the Koch method. Microorganism concentration in such compost is 100 to 1000 times greater than that in very good soil. The greater part of the organisms come from the sludge and, although they came from an anaerobic environment, they are not without significance for aerobic decomposition.

In studies of heat production, at the beginning of composting the mesophiles are active. Characteristic temperature rise slowdowns occurred at 45-55°C, attributed to the fact that in this temperature range the mesophiles cease activity while the thermophiles are undergoing multiplication before producing measurable heat. In practical operation, however, this temporary slowdown is hardly noticeable. It may last longer if the compost has been chilled or overheated as both low and high temperatures for long duration have an inhibitory influence on the rapidity of heat production due to damaged microflora. Initially the rapidity of heat generation is lesser the lower the bacterial count is.

These findings were obtained with use of a homogenic model compost. But in later studies on piles of compost it was demonstrated that the findings were valid for heterogeneous raw refuse also. Temperature curves and microbiological studies in the piles indicated an initial mesophilic phase that ended at about 50°C. After a short time the temperature rose again and occasionally reached 80°C. The week-long heating caused elimination of the greater part of the microflora. This phase may be called the thermophilic or pasteurization phase. During the mesophilic phase the number of species of bacteria involved in heat production reached a maximum then declined with increasingly high temperatures. The sharp drop in mesophilic bacteria at the beginning of the thermophilic phase was followed by further temperature rises involving thermophilic bacteria. But at temperatures exceeding 72°C there was a decline in the CO_2 content of the air in the pores and no appreciable microbial activity occurred. Destruction of pathogens is complete at this phase but the same goal may be achieved at lower temperatures.

The isolation during the thermophilic phase revealed strains of the group Bacillus stearothermophilus (considered variants of B. subtilis), a micromonospora variety of actinomycetes, and the following fungi: Geotrichium (33%), Penicillium (40%), Mucorinae (11%), Sporotrichium and Trichoderma (9%), and Aspergillus (6%). In laboratory experiments with refuse in Dewar vessels at 70°C fungi could no longer be found so it was assumed that they had not survived the high temperatures of the thermophilic phase. However, in heaps reaching 70°C after 4 weeks of decomposition, Aspergillus and Penicillium could be found but other fungus species mentioned above had vanished. In their place dark forms (anaerobes) such as Gliobotrys, Torula, and Phialophora were isolated. The original fungus species in other piles could not be found after 10 weeks of decomposition but other fungus species were present. These must be due to secondary infection.

Upon returning to lower temperatures the mesophilic species evidently became more active in a second mesophilic phase. There is probably no essential change in the thermophiles. Microbiological tests can show whether or not high thermophilic activity has occurred in a sample of compost or refuse but not whether the process of composting has been completed. Two tests might be used to determine maturation. When composting is completed the product should no longer show any thermogenic tendencies, no subsequent heating. Determination of nitrate in compost might be a second possibility. Killing temperatures of nitrite and nitrate bacteria are 45 and 55°C, respectively, and these organisms are non-sporeformers. Ripe compost should be free of nitrites and nitrates. Yet various authors have demonstrated nitrates in finished compost. Either the nitrifying bacteria have not been completely destroyed or they are re-seeded into the compost by wind action. Compost in which the presence of nitrate can be proved is to be considered ripe. The Baden-Baden plant provides a decomposition period of 4 months with one turning. While more frequent turnings may reduce the composting time, it is a question of economics whether the extra labor is justified.

Research has revealed that inoculation of raw garbage with microorganisms is without any results. Raw refuse or refuse-sludge mixtures contain enormous primary flora and attempts to enrich the material with bacteria is like carrying coals to Newcastle. Heavy inoculations with Azotobacter or nitrogen-fixing bacteria were used at Baden-Baden but they did not survive the thermophilic phase. As they do not survive and as they are already present in the raw material, such inocula are useless. The theory that inocula help prevent the formation of anaerobic zones in the piles is erroneous. The black areas are due to oxygen deficiency and not to a lack of certain organisms.

5. Composting from the Hygienic Viewpoint by Dr. K. H. Knoll, Medical Faculty, Justus-von-Liebig Universität, Giessen, Germany.

In the planning and conduct of refuse-sludge disposal hygienic considerations should take first place. Urban refuse normally contains no particularly injurious elements from the standpoint of epidemiology and hygiene. Infections and occupational diseases among refuse workers are almost unknown, even in manual sorting of the raw refuse. Normal refuse is not dangerous from the pathogenic aspect but rather may possess bacteriostatic or bactericidal activity. But certain requisites must be filled on esthetic and hygienic grounds in the storage, collection, and utilization or disposal of refuse. Greater care should be taken to prevent contamination of surface and ground waters from either regulated or haphazard refuse dumping.

Settled sewage sludge offers greater danger regarding pathogenic considerations. Normal domestic sewage must be considered as infected with pathogens due to carriers, even if the highly infected residues from hospitals, sanatoria, and doctors' offices are disinfected at bedside. Sludge can be made sanitary by pasteurization at 100°C but heat treatment is generally uneconomical.

For the treatment of sewage sludge by a sanitary and economical method, joint treatment with refuse appears desirable and saving in space. Thus, refuse-sludge composting seems to be a procedure which complies with all requisites in an ideal manner. It can be compared with the self-purification of streams by natural biological processes. Bacteriological evaluation of the composting process based only on laboratory tests is just as unacceptable as the fixing of lethal temperatures for pathogens without considering the time factor and antagonistic principles occurring during composting. The aim of the Baden-Baden investigations was to obtain knowledge for hygienic evaluation of refuse-sludge composting and to eliminate present misconceptions about the process. It was assumed that refuse and sludge were both infested with pathogenic microorganisms and worm eggs.

During the first summer and winter field trials, mixed cultures from sewage and drainage ditches were put in gelatine capsules, packed with 100 g of raw material in perlon (nylon cloth) bags, and inserted into the trial stack at three different points. These cultures contained the following strains of Salmonella:typhi-murium,cairo, infantis, and typhi. Control bags were also kept refrigerated for the duration of the tests. At the first turnover of the piles, i.e. after 50 days of composting, all pathogenic organisms had been wiped out, whereas they were still demonstrable in the controls.

Golueke and Gotaas reported lethal temperatures of 60°C and higher for pathogens but took into consideration neither the time factor nor the microbial antagonistic effect in the piles. It was clearly evident in the Baden-Baden experiments that pathogens were eliminated even when the temperature did not rise above 60°C. Other factors must therefore be playing a role if the elimination is not due entirely to the thermal factor. Some of these are physical, as the water content, and others biological. Pathogen resistance is greater in dry refuse than in moist. A sufficiently high moisture content of the material to be composted is a requisite for sanitary composting.

Further field and laboratory trials were made to study these effects. It was shown that at a constant temperature of 50°C S. paratyphi B. was eliminated from the heaps by the second day and S. cairo, more resistant, by the 7th day at 50% moisture content. Control cultures stored at 30°C and 50°C in incubators still showed living S. paratyphi B. after 8 days and S. cairo after 17 days. These results show that it is not simply a physical-thermal process leading to pathogen elimination but that antagonistic effects produced by antibiotics are present.

To demonstrate the antibiotic effect, aqueous extracts were made from compost, sterilized, and mixed with bouillon. These extracts were inoculated with pathogens and stored at 50°C. While in the control (beef broth plus bacteria) S. paratyphi B. was active after almost 4 weeks, they could not be found after 10 days in the compost extract-beef broth. Parallel experiments with S. cairo yielded the same results except that the killing time was 14 days.

Sensitivity tests were then conducted that were like the usual tests for determining the resistance of certain pathogens to antibiotics. Extracts were vacuum freeze-dried, lyophilized, and tested on selective media for pathogenic bacteria by the "stab" test. These tests clearly indicate that several antibiotic components are active with the result that the final compost is acceptable from the pathogenic viewpoint.

It was concluded that the hygienic requirements are largely fulfilled by the regulated composting of refuse and sludge. The biological self-purification processes are carried out by composting, eliminating the hazardous features, and returning to the soil an ideal medium for its improvement. In the future it may be possible by regulating temperature of decomposition to simultaneously meet the requirements of the hygienists, technicians, and farmers, producing a compost more valuable and easily distributed while still meeting hygienic requirements in every way.

6. The Influence of Organic Fertilizers on the Uptake of Mineral Nutrients by Plants by Prof. Dr. W. Sauerlandt, Institut für Humuswirtschaft, Bodenfruchtbarkeit und Pflanzenernährung, Forschungsanstalt für Landwirtschaft, Braunschweig-Völkenrode, Germany.

A three-year trial with sugar beets, oats, and rye was conducted to determine the influence of rasped fresh and composted refuse on the uptake of nutrients by plants. Experiments were made with Dorr-Oliver process material from Heidelberg (grinding in a rasping machine followed by windrow composting). Plant growth and yield are strictly dependent upon the absorption of nutrients from the soil. Variable factors are also involved such as the influence of climate, physiological characteristics of plants, variations of nutrient content of the soil at different depths, and the transformation of organic matter in the soil. However, in these experiments using the same plots of land and the same plants, the only variable factor was the influence of the refuse upon the yield and nutrient uptake. Consumption of nitrogen, phosphorus, calcium, magnesium, and potassium was measured. Because no significant differences were found in the case of magnesium and potassium, only the uptake of the first three nutrients will be discussed here.

The nutrient contents of refuse and refuse compost are quite well known. Yet little is known about the structure of these nutrients and about the organic products resulting from the decomposition of compost in the soil. It is calculated that for every 100 kg of cellulose broken down about 0.3 to 0.5 kg of phosphorus is assimilated by the microorganisms. A considerable portion of the phosphorus in refuse compost is in the form of organic compounds, probably nucleic acids.

Various plots were treated with 100 metric tons per hectare (44.6 T/acre) of ground refuse (raw and composted) besides a uniform mineral fertilizer. The following changes were than found to have occurred in the organic carbon content of the soil:

Soil Treatment	Milligrams of Carbon per 100 g of Soil: Initial	After 7 Months	After 11 Months	After 16 Months	After 28 Months
Without refuse	890	959	937	902	906
With refuse compost	1,220	1,209	1,156	1,064	1,047
With fresh refuse	1,248	1,232	1,060	1,084	1,095

The organic matter of the fresh refuse was quickly decomposed during the first year of the experiment (after 6 months, about 25%; after 12 months, about 65%). The active (effective) organic substances of the raw refuse were nearly completely broken down with a year's time.

The calcium intake by the plants during the first experimental year was considerably higher for the plots containing raw refuse than for those without refuse or with refuse compost. During the second year a considerable after-effect was found associated with an increased uptake of nitrogen and phosphorus. During the third year the yield and nutrient intake declined as opposed to the composted refuse while the raw refuse showed a definite, though limited, action. The after-effect, particularly during the third year, was smaller in regard to crop yield than in regard to nitrogen and phosphorus uptake.

On the other hand, the composted material was decomposed considerably slower in the soil; the nutritional requirements of the plants were fulfilled over a longer period. The after-effect, measured in terms of yield was nearly the same for the two years following application. The after-effect of refuse compost was less than that of fresh refuse with respect to plant uptake of nitrogen and phosphorus. In contrast to raw refuse the influence of refuse compost on the yield was greater than on the nutrient intake during the second followup year.

	Effect of Raw Refuse and Compost on Yield: Relative Value (without refuse) = 100. Refuse Compost	Fresh Refuse
Initial effect (1956)	117	117
1-yr. After-effect (1957)	109	114
2-yr. After-effect (1958)	111	104

Treatment with compost resulted in a longer-lasting source of nutrients than treatment with raw refuse. Analyses of yields and nutrient uptakes show that when compost was used other substances also acted in the increases in yield and growth.

The influence of organic substances on nutrient uptake can be attributed to two phenomena:

(1) The greater availability of nutrients in the soil due to organic anions, which can be induced by complex salt formation, or selective absorption.

(2) The exertion of a physiological influence on plant growth by certain organic substances. It has long been known, for example, that humic acids promote root growth. Flaig and co-workers have shown that cold water extracts of finely ground wheat straw contain aromatic acids as decomposition products of lignin such as p-oxybenzoic acid, vanillic acid, p-oxycinnamic acid, and ferulic acid. These aromatic acids are able to promote growth, yield, and nutrient uptake.

By means of long-term field experiments and based on these results, it should be possible to determine the quality of different types of refuse. However, it appears necessary to determine not only the yields but also the nutrient uptake and the organic substances contained in the crops. Comprehensive soil analysis is imperative. These trials show with regard to fresh refuse application that there were hardly any differences in the first year while brisk mineralization in the second year resulted in favorable results. Composted refuse produced positive results during the third year as opposed to raw refuse, the effect of which had already diminished.

7. Humus and Root Activities by Dr. L. K. Wiersum, Institute for Soil Fertility, Groningen, the Netherlands.

Results with solution cultures and sterile root media have shown that only water, carbon dioxide, and a number of mineral elements are essential to growth of plants. The soil in general contains a varying amount of organic matter from fresh plant and animal remains to relatively stable end products of decomposition, the humus. There are enormous numbers of widely different organic compounds in the soil including small, easily soluble molecules and large polymer molecules often insoluble in water. As organic molecules up to a molecular weight of 600 can enter the root system of plants, many of the smaller molecular organic substances in soil must be reckoned with. The importance of these substances on stimulating root growth and metabolic activity and as accessory nutrients will be considered, particularly with respect to humus. Humus is the term for the more or less stable, brown-colored end products of decomposition of organic matter.

The rate of absorption of nutrient material is proportional to the total active area of the roots. Ability to absorb is usually confined to the young parts of the root, usually having root hairs. The volume of soil in contact with these parts is not more than 1% of the volume of soil occupied by the roots. Consequently, roots must continually keep growing to be able to tap new nutrient sources.

The moisture of the soil is one of the most important factors in root growth. Humus and other organic polymers can absorb much water and by so doing increase the moisture reserves and available water in the soil. They also influence soil structure (friability) favorably, minimizing water losses and preserving the oxygen supply to the roots and acting favorably on root growth. Soil is not homogeneous with regard to nutrient content. There are not only differences between layers of soil at different depths but also locally within the same layer. Thus a thorough penetration of all parts of the soil by rootlets is a prerequisite for good plant growth. Experience in almost all soils shows that those with the highest humus content also have the most prolific root growth. Recent studies showed that the formation of secondary roots is stimulated more by contact with peat than with sand and resinous ion exchangers. The explanation may be that the high concentration of adsorbed ions at the surface of the humic substance acts as a stimulant. It has also been shown that of the separate ions nitrate was most active in inducing dense branching. Humus constitutes one of the main sources of stable nitrates in the soil.

Aqueous extracts of soluble humus and sodium humate favorably influence root growth but not under sterile conditions. The author's experience showed that an increased root growth of lepidium(?) is obtained with humus extracts. Results depend upon the nature of the extracts, whether humic of fulvic acids, and on the purity and concentration of the extracts. Occasionally inhibition of growth is also observed. Flaig and co-workers at Braunschweig-Völkenrode have tested synthetic pure substances analogous to intermediates in humus decomposition. A whole series of quinone derivatives promoted root growth but again there were negative results in some cases. Stimulation of root growth by these compounds should have a favorable influence on the nutrient uptake and growth of the entire plant.

We still lack complete understanding of the variable but generally favorable influence found in these experiments. Flaig et al were intensively concerned with the physiological changes induced in the plants by the intake of these pure substances. Part of the favorable effect can be attributed to the chelate-forming ability of humus compounds. Certain minerals, particularly the heavy metals (trace elements), can be more easily absorbed by plants in the form of chelates than in the organic form.

In a soil well-provided with nutrients the physiological functioning of the roots determines the assimilated nutrient quantities, as assimilation and transportation of nutrients are energy-consuming processes. It is therefore important to learn more about the influence of humus and other organic substances on root function. The Russian authors Christewa and Kononowa found that humus exerts an influence on the respiration and oxidation-reduction process of the plant. According to Saalbach various test substances, all quinone derivatives, increased the activity of various enzymes such as aldolase, amylase, saccharase, phosphatase, and tyrosinase. Aleshin and Tyuneeva asserted that the substances present in humus extracts were actually absorbed by the roots. This effect was traced to the quinoid structure of those substances by both German and Russian authors.

Blanchet reported that a considerable increase in assimilation of nitrogen, phosphorus, sulfur, and potassium was found in the presence of humus. The humic acids also increased potassium absorption by root colloids, thus a part of this effect may be ascribed to an increased permeability of the root membranes caused by the humus.

In general, it can be stated that many of the organic substances present in the soil and in compost influence the physiology of the roots. Their effect may be harmful or beneficial depending on the nature and concentration of the substances.

/Ed. note: The final two paragraphs of the English translation of the author's complete paper are quoted as an addition to the above summary./

"Although the normal higher plants can thrive when being fed with mineral nutrients only and organic substances are in no way essential, yet in farming and horticulture much importance is attached to them. Besides the supply of mineral nutrients they carry and which is freed during the mineralization process, humus and organic matter have been shown to possess specific stimulating capacity. These facts may partly explain some of the favorable influences attributed to a high humus content, although influences relative to improvement of physical soil factors are very important.

"However it all may be, in general a farmer will be wise to complement mineral fertilization with measures inducive to retaining or improving the humus content of his soil. Application of good composts, if not too expensive, may be one of the methods to achieve the desired result."

8. Long-Term Effects of Urban Refuse Compost by Engr. J. Kortleven, Institute for Soil Fertility, Groningen, the Netherlands.

A distinction can be made between short-term and long-term effects of organic fertilizers. The short-term effects are similar to those of mineral fertilizers and are due to the decomposition of unstable organic and inorganic matter soon after application. Long-term effects, however, are based on an increase in the humus content of the soil. They are called long-term effects because it takes a considerable time before an increase in humus content of the soil can be noted after application of organic matter and it takes just as long to detect a reduction in the soil humus content due to decreased application of organic matter. This paper deals with the relationship between the use of refuse compost, the humus content, and the productivity of the soil.

Omitting special cases, such as marsh or bog soils, the average humus content of Dutch soils is about 4% with a certain deviation about this average value. There is strict correlation between the humus content and productivity; this correlation is difficult to express quantitatively because humus is not a simple growth factor and because it is a long time before one can detect an increase in soil humus content in such experiments. Sometimes, because trials have not been of sufficient duration, the erroneous conclusion is reached that the humus content of a soil cannot be modified or changed.

In two trials conducted in Holland it was found that the optimum humus content of soil for potatoes amounted to 7 to 8% or double the average amount present. The optimum humus content varies from 2 to 17% depending upon other factors to a great extent, such as the structure, the clay content, ground-water level, etc. These trials also showed that a principal function of humus is moisture content regulation when other factors are deficient in this respect. There is an optimum humus-moisture content and productivity drops again when excess water is present.

If we calculate the change in humus content of a hectare of soil with 4% humus and a topsoil weight of 2,000,000 kg after an application of

20,000 kg/yr of stable manure over a 10-year period, the result is 4.35% (assuming a supply of 3,000 kg/yr of organic dry matter from harvest residue). It is quite clear that such a small increase as 0.35% is difficult to detect by analysis and that is why the opinion is so often encountered that stable manure does not increase the humus content of soil. The 0.35% increase nevertheless represents 7,000 kg of humus or 25% of the organic matter contained in the 200,000 kg of stable manure applied. The 25% figure can be consistantly determined.

These calculations show that the humus content increases very slowly and requires application of large amounts of organic matter. The more the soil humus content is below the optimum value, the more it will be increased by an application of organic material. At the optimum level, there is no longer any increase because here the additional supply and decomposition reach a state of equilibrium. If the above rate of application were to be continued for about 150 years, the humus content of the soil would be 5.9%.

In the above example stable manure was the organic fertilizer applied. However, for balanced agriculture it is undesirable to use stable manure continuously and exclusively as the organic fertilizer because such practice can result in dangerously high accumulations of some substances and deficiencies in others. This is also true for organics such as harvest refuse and green manures. Because of difficulties encountered in attempting to make all organic substances available within the farm (green manure, crops, crop rotation, etc.) the simplest method is the use of products produced outside the farm such as urban refuse compost.

It has not been explained yet how different organic fertilizers function in relation to one another regarding the increase of soil humus content. The various kinds of crops have yet to be analyzed in this respect. Such long-term analyses are now being made in Holland but are not yet completed. Provisional results show that the increase in soil humus contents are of the same order of magnitude for the various organic materials (green manure, etc.).

The use of 10,000 kg/hectare/yr of refuse compost on a soil with 8% organic matter having a humus content below the optimum value increases the humus content by 0.8%/yr and the productivity by 3.6%. To assess the profitability of this procedure, the short-term effects and the value of commercial fertilizers saved must be included in the calculation. Although these effects decrease in importance the longer an organic fertilizer is applied (because gradually the existing deficits are being eliminated), there still remains a residue and it may be assumed that the total effect is 5 to 10% increase in productivity.

There is still much that is not clear regarding long-term effects but more and more opinions hold that the moisture-regulating function of humus is the most important factor. The author would like to attribute some value to humus as a nutrient binder. In addition the nitrogen content of the soil to which compost has been applied increases proportionally to the humus content.

The soil content of magnesium and phosphorus, as well as the pH value, also vary with prolonged use of compost. Despite an increase in soil phosphates, the solubility of the phosphoric acids declines. The pH increase makes the use of compost for long periods of time difficult in soils that are either slightly alkaline or acid. The pH increase in Holland amounts to about one unit per 2,000 metric tons per hectare. [Ed. note: this is probably due to the high content of ashes in Dutch refuse.]

It is criminal to burn refuse instead of returning it to agriculture where all sources of organic manures are insufficient to maintain the optimum humus value in the soil. This should be given due consideration in deciding the practicability of methods of refuse disposal.

9. Production and Utilization of Urban Refuse Compost in Subtropical Countries by A [illegible]ivshutz, Chemical and Technical Supplies Ltd., Tel Aviv, Israel.

In the semi-arid subtropical regions the soil fertility is completely dependent upon irrigation. As a water shortage always exists, any means permitting a reduction in irrigation water is welcomed. Compost is desirable for this purpose because of its great water-holding capacity. Use of compost can reduce irrigation water by 10% permitting a 10% expansion in irrigated areas. The higher temperature and moisture content of irrigated subtropical soil contribute to more rapid breakdown of organic matter. Soils poor in organic content generally show poor physical structure which acts unfavorably on plant growth even in the presence of adequate nutrients. Organic matter must consequently be added continuously, mostly in the form of stable manure and compost. Yields in Israel can be increased 5 to 10% by the use of compost.

Much compost has been recently used in Israel in citrus groves, vineyards, and in growing bananas, potatoes, and strawberries. The demand is increasing and is now greater than the supply. In 1958 a total of 120,000 cu m was used in citrus groves alone. The compost is broadcast and results in 15 to 20% production increase even though heavy applications of mineral fertilizer were made in previous years. Also the appearance of chloroses (yellow leaf) was avoided and the quality and taste of the fruit was improved. Yearly consumption of mineral fertilizers was reduced 25% through the use of compost.

Other crops (bananas, potatoes, strawberries) achieved increased yields with compost application. Farmers prefer compost over all other organic fertilizers including stable manure, once they have used it. Experiments are now being conducted on compost use as bedding for cattle and poultry as well as for fish food in carp ponds.

There are two large plants producing compost in Israel. One plant uses refuse accumulated for many years in heaps about 4 m high. The decomposed refuse is dug up and screened. This compost contains some glass and china splinters, nails and other metal pieces. It therefore cannot be used in pastures or gardens but is good in vineyards and orchards.

The second plant pre-sorts the refuse which then passes through a Dorr-Oliver rasping machine and is composted in windrows which are turned 4 to 6 times. The first turning is done within 3 days to destroy fly larvae and prevent anaerobic decomposition. At the second turning, 2% of natural phosphates and also sewage sludge are added to give a moisture content of 50-60%. Ballistic and magnetic separators refine the compost after 20-25 days of decomposition.

The question as to when compost is mature continually arises. Investigations by agricultural research stations at Rothamstead and in New Jersey showed better yields and soil improvement in many cases with non-composted organic matter than with ripe compost. Yet crop damage may result with use of compost that is only partially decomposed. Refuse should be decomposed at high temperature for a time to meet hygienic requirements. By experiences in Israel, a composting time of 2 to 3 weeks at 60-70°C is sufficient when the moisture content is optimal (40-60%) and care is taken for good aeration of the windrows (windrows not higher than 1.5 m or wider than 3 m and frequently turned). A C/N of about 25 is considered optimal; if higher, nitrogen is added.

The following conclusions are drawn from the experiences in Israel:

> Compost should be marketed and used not as a fertilizer but as a means of soil improvement.
>
> The purchaser should be informed that compost use does not lead to positive results as quickly as fertilizer. Compost shows results a year after application.
>
> Composting of urban refuse in subtropical lands should be encouraged by the authorities as it is of great importance in sanitary and agricultural improvement of these countries.

10. Processing and Agricultural Utilization of Urban Refuse in France by Engineer M. Neveux, Chief Engineer, Department of Agricultural Engineering, Paris, France.

The amount of organic matter incorporated into French soils yearly is about 40 to 50 million tons (metric). By comparison the annual production of stable manure is about 100 million tons. If each town of more than 20,000 inhabitants had a composting plant and a sewage treatment plant, an additional 0.5 - 0.75 million tons of organic matter would come from refuse and 0.15 million tons from sewage sludge.

Little use is being made of refuse and sludge for agricultural purposes as compared to stable manure. Setting aside the statistics and considering that refuse compost is destined for those regions of France where the need is greatest, it is seen that compost would play an important role in development and maintenance of soil fertility.

In the Paris region, 200,000 to 400,000 tons of raw refuse are freed from iron and glass fragments, pulverized, and dispensed immediately to farmers. The finely ground product is homogeneous, easily applied, and comparable to stable manure in fertilizing value. The raw compost is plowed into the soil in autumn. Application rates are: sugar beets and potatoes - 50 to 80 tons/ha; truck gardens - 100 to 200 T/ha; vineyards - 80 to 100 T/ha; orchards - 150 to 200 T/ha; and tree nurseries - 200 to 250 T/ha.

Transportation costs are high because of the low density of raw refuse. Practical use therefore depends largely on distance between plant and place of consumption. Compost is comparable to good stable manure in quality and is usually much cheaper. The price of stable manure in France is somewhat higher than its true value whereas the prices of compost and raw refuse are considerably below their true values. Also stable manure is difficult to obtain in the vicinity of cities. Compost is easily obtained in regions lacking manure except in cattle-raising regions where difficulties exist, partly as a result of lack of publicity and information. Generally speaking, refuse compost is used in agriculture mostly in the south of France which has a warm, relatively dry climate and where most of the composting plants are also located.

11. A Contribution to the Evaluation of Organic Fertilizers by Prof. J. Keilling, National Institute of Agronomy, Paris France.

It is very difficult to evaluate the quality of fermented or partly fermented organic matter such as refuse compost because the processes of fermentation are themselves too little understood. Yet the consumer of such a product deserves to be informed about its quality.

A simple chemical analysis does not alone suffice in evaluating an organic fertilizer because it does not take into account its microbiological activity. Methods have been sought at this Institute which were in use in other fields involving fermentation and that could be adapted to compost evaluation, such as the reductase and phosphatase tests. The former permits following the course of composting and the latter estimates the enzymatic activity of the microorganisms present or added to the soil or compost. The experiments are not yet completed but preliminary results are very promising.

It can be assumed that in decomposing compost there are many hundreds of millions of microorganisms. It is known that many organisms produce auxins (plant growth factors). In an experiment aqueous extracts of raw refuse and refuse decomposed for 24 hours were added to cultures of Diplococcus in sterile milk. The bacterial counts increased 6 times as much in the extract from decomposing refuse as in the raw refuse, an effect traceable to the positive effect of auxins on the Diplococcus. Roberts, in 1939, found that 66% of 150 microorganisms isolated from the soil produced auxins.

Auxin production during decomposition or fermentation of organic material poses the following questions which require answering:

What auxins and in what quantity are produced in refuse compost?

Are these auxins formed chiefly during the process of decomposition or only afterwards when the compost is incorporated into the soil?

At what stage of development of the plant do auxins have the greatest effect on the plant growth?

Is there a critical amount which, when exceeded, can cause damage, and can this amount be determined simply and easily in compost?

Our tests now in progress appear to indicate that the phosphatase test can show some results in this direction.

12. Summary of Discussions

The following summarizes the discussions held after the conclusion of the speeches, grouped according to subject matter. Names of each participant in the discussions are omitted as well as questions not directly connected with the theme under discussion.

(1) Joint Treatment of Sewage Sludge.

That the problem of concomitant processing of refuse and sludge constantly becomes more urgent in all countries was emphasized by the discussions. Dr. Jaag spoke on the circumstances in Switzerland, Dr. Straub on those in Germany, and Engineer Weststrate on those in Holland regarding the status of joint treatment. Sludge is not normally used at any of the five composting plants in Switzerland but large-scale experiments have been conducted by EAWAG at the Rüschlikon (Dano biostabilizer) plant and at the Uzwil (Bühler process) plant. These showed that composting of refuse and sludge in equal amounts is possible provided only that the sludge is dewatered to a moisture content of about 70%. Experiments with raw sludge showed better results than with digested sludge because of more intensive decomposition and better quality compost. Undoubtedly the moisture content should be reduced still more for raw sludge if equivalent amounts are to be used. In Germany the addition of digested sludge is a normal operating procedure at the Baden-Baden and Duisburg plants, in Holland at Enschede, but not in equivalent amounts so that the sludge need not be dewatered to such an extent. Dr. Rohde (Berlin) reported good results with sludge composting without refuse. He composted large quantities of (digested) sludge from the Berlin sewage treatment plant by dewatering it on drying beds to 70% moisture, plowing it many times, and finally composting in windrows at a moisture content of about 60% in the usual way. Windrows are provided with aeration channels to better provide oxygen.

(2) Compost Tests.

Works Superintendent Horstmann asked about a uniformly applicable, simple test for compost. Such a test should include the nature of refuse- and refuse-sludge-compost as a soil conditioner, the physical and biological characteristics, and especially the degree of maturation. The IRGR Secretary said one of the chief tasks of IRGR is to standardize research methods and develop biological tests. He will send to all IRGR participants a list of all methods of analyses in common use to serve as a basis for authoritative discussions. A symposium will probably be held next year to which all experts in the field of compost research will be invited.

The question of the present existence of criteria regarding the quality of compost or rules for its production must be answered in the negative. The heterogeneous raw material (refuse and sludge) makes it impossible to guarantee specified contents of effective organic matter, nutrients, and trace elements. This is why compost should be classed as a soil builder rather than a fertilizer.

(3) Economic Comparison of Different Composting Processes.

The critical question as to whether the grinding (rasping) or the Dano process is more economical cannot be directly answered as it depends upon many factors that must be individually tested and analyzed in order to find the best solution for a given community. Direct comparison of the economics of various existing plants is difficult not only regarding construction and operation costs but also regarding special circumstances which vary from place to place such as selling problems, interest rates, etc.

(4) Processing Urban Refuse for Agricultural Use.

Mr. G. Dobrouchkess, IRGR representative in France, read a report by Mr. J. W. Partridge, Honorary Chief Engineer of Technical Services, Paris, which is summarized as follows:

> The processing problem of refuse composting is largely solved but this is not true of the regulation of the decomposition to produce a product meeting hygienic requirements in a short time in order to save space. Some of the problems pertaining to decomposition and their possible solutions will be described.
>
> Anaerobic decomposition, as with sludge, is discarded mainly because of the slowness of the process and the insanitary end product. Although aerobic decomposition of the refuse is much more intensive, the time required to obtain ripe compost still varies between 3 months and a year. An urgent problem is therefore to decrease time of decomposition which can be accomplished in the following ways:
>
> > Adjustment of environment: Of greatest importance here is the optimum moisture (40-60%) of the decomposing material. While nitrogen addition in any form may intensify decomposition (reducing C/N), the desired effect is accomplished only at exorbitant costs except by the addition of sludge. Addition of other materials, such as peat, phosphates, etc., has not proved satisfactory.
> >
> > Physical changes: Ground organic matter is more rapidly decomposed than large chunks of matter; but because of poorer circulation of gases in heaps of finely ground material, more frequent turning is required.
> >
> > Aeration: This can be obtained best by frequent turning of the windrows and limitation of their height and width. Systems with artificial aeration are generally too costly.

Inoculation of refuse: Waksman has shown that the best inoculation is accomplished with decomposed material. Inoculation of fresh refuse with bacterial cultures is too costly and their worth is very doubtful.

Temperature: Care must be taken to insure initial temperatures of over 50°C in the windrows to insure intensive decomposition and a sanitary product. Temperatures over 80°C should be avoided as they also kill the thermophilic bacteria.

Prefermentation: Preliminary decomposition of raw refuse in suitable containers can considerably accelerate decomposition; a good mixing of the various materials, and thereby a homogeneous product, is also obtained.

Addition of Sewage Sludge:

The addition of sewage sludge imparts considerable improvement to refuse composts. Difficulties arise from the high water content of the sludges; therefore they must generally be partially dewatered in advance. The mixing of sludge and refuse offers the best possibility of their sanitary disposal; but the associated technical problems have not yet been satisfactorily solved.

(5) Refuse composting in the U. S. A.

The discussions concluded with the showing of colored slides by Mr. John Wiley, Sanitary Engineer, U. S. Public Health Service, Savannah, on refuse composting in the U. S. A. We express the hope that Mr. Wiley will publish his interesting papers occasionally in our Information Bulletins.

Information from the Secretariat

Congress Papers: All Papers are available in a brochure in French, German and English from the International Agricultural Centre, 1 Gen Foulkesweg, Wageningen, the Netherlands, at a cost of 25 guilders ($6.70).

Slide Collection on Refuse Utilization: The Compost Foundation, Amsterdam, has made up a series of 50 excellent (2 x 2 in) slides on collection, processing, and utilization of refuse. An accompanying brochure contains detailed explanations of the slides and an interesting article on refuse processing in the Netherlands. The slide series with brochure can be purchased for 50 guilders ($13.40) from: Stitching "Compost," Jac Obrechtstraat 67, Amsterdam, the Netherlands. We highly recommend this excellent documentary material. Stock is limited.

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March 1960

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1. Structural Analyses of Compost Piles by Dr. C. Tietjen[1] and Dr. H. J. Banse[2]

Control of the air supply is of fundamental importance in composting community wastes in piles. Control is provided in various ways which generally only aim at insuring that the "Luftquantum" (amount of air) (according to Wollny) required for decomposition is not less than the minimum. Unsorted refuse can be laid down in higher piles because the bulky components assure loose packing and therefore sufficient aeration and exchange of gases. Sorted refuse frequently requires aeration initially as by means of a blower or natural aeration through perforated pipes beneath the windrows. Piling of refuse after processing, as in the Dorr-Oliver rasping machine (refuse treator) or in the Dano drums, causes certain difficulties. Gas exchange, necessary to avoid formation of a "black"core (anaerobic zone), requires windrows to be low and narrow with the height dependent primarily on the composition of materials and the moisture content. When windrows are too high, the considerable labor expenditure for repeated turning cannot be avoided if anaerobic conditions in the interior are to be eliminated.

Maier et al(1) studied the oxygen content of the air in piles and recommended wire mesh containers (aeration bins) about 75 cm wide x 120 cm high for composting ground refuse in order to maintain aerobic conditions. Snell(2) investigated oxygen requirements for aerobic composting of organic wastes. His co-worker, B. J. Shell, reported (1955) that with materials of various pore volumes the amount of oxygen capable of being supplied by diffusion was only 0.5 to 5% of the total oxygen requirements. The experiments were conducted with ground garbage in (laboratory) composting drums.

Knowledge of total pore volume is necessary for such experiments, particularly the water-free pore volume which alone permits gas exchanges, as well as routine analysis of pile air.

Pore volume in compost piles can be measured by the compressed air pycnometer developed by von Nitzsch(3) for determination of coarse structure of arable soils. The method assumes that samples correspond to the "natural" deposition of the materials (undisturbed cores). The structure in a compost pile is more susceptible to destruction than that in soils by the usual driving of sample cylinders to obtain core samples. Sauerlandt, therefore, developed an apparatus with which a Burger cylinder(4) can be inserted with less compressing force.

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[2] Bodenverbesserungsverband (Soil Improvement Assn.), Bad Kreuznach, Germany.

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The apparatus (figure 2) consists of a tripod with an arm, shaft, and cutting cylinder. A sampling cylinder (1000 cc) is inserted within the cutting cylinder. The blade is at least 4 cm long and unilateral. At the blade the open width of cutting cylinder is the same as that of the sampling cylinder so that a core can slide into the latter without deformation. The cutting cylinder projects about 4 cm beyond the sampling cylinder. To prevent the latter from slipping during sampling, a ring of the same diameter and thickness is placed on the sampling cylinder. The cutting cylinder is closed with a lid by two small studs which fit slots in the cutting cylinder. This permits rotation of the cylinder into the material after reaching the desired depth and separation of the two cylinders by means of a slight jerk in the opposite rotational direction. The shaft is held by a guiding rod supported by an arm fastened to the tripod with wing screws which enable adjustment of height.

The cutting cylinder is rotated vertically down to the cover in the leveled material to be sampled. The cutting cylinder is then freed from the material with a serrated knife and the inner cylinder with sample is removed. The sample is trimmed flush with the cylinder end and enclosed by two lids. Fresh (damp) volume is determined with the compressed air pycnometer(3). Determinations of moisture content and dry matter volume are done by the usual methods.

Densities of piles of stable manure composts(5) and of refuse composts were measured in the manner described. The former had been prepared with a manure spreader with thorough mixing of fresh manure and soil in a ratio of 4:1 and had been piled in wire bins for two, four, or six months at the time of sampling. Decomposition of the mixture is reflected by the diminishing content of organic matter:

Composting time, months	2	4	6
Organic matter content, %	9.7	9.2	8.2

Twenty samples for the determination of pore volumes yielded the values shown in table 1.

Table 1

Fresh Weight, Dry Weight, and Fresh Volume of Stable Manure Compost (1000 cc samples)

Pile	Decomposition Time, months	Fresh Wt., g	Dry Wt., g	Fresh Volume cc
I	2	933	328	737
II	4	1033	352	823
III	6	1075	369	855
Smallest measurable difference in fresh volume: 25(P=5%) and 34(P=1%).				

Volumes of air, water, and dry matter can be calculated from the values in table 1 as shown in table 2.

Air volume ≈ cylinder volume (1000 cc) - Fresh Volume
Water volume = Fresh weight - Dry weight
Pore volume = Water volume + Air volume
Solids volume = Fresh volume - Water volume

Table 2

Volumes of Solids, Water, and Air in Stable Manure Compost

Pile	Decomposition Time, months	Volume in Percent			
		Air	Water	Pore	Solids
I	2	26.3	60.5	86.8	13.2
II	4	17.7	68.1	85.8	14.2
III	6	14.5	70.6	85.1	14.9

No definite influence of decomposition time was shown in the densities. Average values for the three piles were (g/cc):

Density of fresh matter	1.26
Density of dry matter	0.43
Specific gravity	2.48

Winter refuse compost was analyzed after five days of decomposition in a Dano biostabilizer followed by 6 or 9 months of curing. Five samples each were taken from eight depths of piles almost 2 m high in order not only to differentiate between 6-mo and 9-mo curing but especially to determine the physical structure within the compost heaps. Average values of the 40 determinations in each case are shown in table 3.

Table 3

Structure of Refuse Compost after Six and Nine Months of Curing (1000 cc samples).

	Unit	6 Months	9 Months	Average
Fresh weight	g	816	804	810
Dry weight	g	675	671	673
Water weight	g	141	133	137
Water volume	%	14.1	13.3	13.7
Fresh volume	%	41.7	40.2	40.9
Air volume	%	58.3	59.8	59.1
Pore volume	%	72.4	73.1	72.8
Solids volume	%	27.6	26.9	27.2
Fresh density	g/cc	1.96	2.00	1.98
Solids density	g/cc	1.62	1.67	1.65
Specific gravity	g/cc	2.45	2.49	2.47

These results show no significant difference in compost structure between six and nine months of curing. The pore volume, average of 80 determinations, amounted to 72.8% with 59.1% being water-free, air-bearing pore volume.

Yet there are definite structural differences shown within the compost piles. Figure 1 and table 4 show that, independent of the storage time, the total pore volume was about 72.5%. In both piles the maximum air volume was at moderate depths, about 70-100 cm, and the maximum water volume was at the bottom. The change to high water content occurred abruptly at the bottom in the older pile while in the 6-month pile the water content increased at the expense of air space even in the middle depths. Also, the older pile showed a layer with high water-low air content near the surface. This stratum is reminiscent of the water condensation zone frequently observed in composting piles. It is not understood why the younger pile does not show this stratum as the 6-month period should be sufficient (to develop the stratum). As the experimental piles were established three months apart and decomposition was not for the same time, the weather may have influenced them differently.

Structural analyses in compost piles require supplementation by other investigations, especially gas analyses. The designation of water-free pores as "air volume" is conventional. However, numerous analyses of the "pile air" in the two piles showed that the exchange of gas is limited in the range of about 40 to 70% air volume found here. Thus, the oxygen content at 1-m depth in the older pile was more than double that in the younger pile (table 5). The bottom stratum in both piles was colored black, indicating persistent lack of oxygen in this region.

Table 4

Percent by Volume of Air, Water, and Solids by Depth in Refuse Compost Piles

Volume	Stratum, cm from the top								
	0-30	30-50	50-70	70-90	90-110	110-130	130-150	150-170	Average
After 6-month Curing									
Air	60.0	62.0	62.1	65.7	65.2	58.1	50.8	42.3	58.3
Water	11.3	9.5	9.6	8.7	9.9	15.9	22.1	26.3	14.1
Pores	71.3	71.5	71.7	74.4	75.1	74.0	72.9	68.6	72.4
Solids	28.7	28.5	28.3	25.6	24.9	26.0	27.1	31.4	27.6
Smallest measurable difference in air volume: 3.6 (P=5%), 4.9 (P=1%)									
After 9-month Curing									
Air	54.0	48.2	61.6	66.0	65.1	67.9	66.6	48.8	59.8
Water	19.4	22.4	11.1	7.7	7.3	7.5	9.1	21.6	13.3
Pores	73.4	70.6	72.7	73.7	72.4	75.4	75.7	70.4	73.1
Solids	26.6	29.4	27.3	26.3	27.6	24.6	24.3	29.6	26.9
Smallest measurable difference in air volume: 3.2 (P=5%), 4.3 (P=1%)									

Table 5

Percent by Volume of Oxygen and Carbon Dioxide of Pile Air by Depth

Stratum, cm from the top	Pile 1 6 Months Old		Pile 2 9 Months Old	
	O_2	CO_2	O_2	CO_2
0-40	17.2	3.0	19.2	0.8
40-80	13.8	6.0	18.8	1.4
80-120	8.2	9.8	17.8	2.4
120-160	2.4	12.0	16.6	3.6

Sampling pile air with a series of analyses is possible such that the analysis is sufficiently representative for the site of withdrawal. However, as the composition of pile air at various depths shows considerable differences and the results do indeed indicate conditions at the time, they may be influenced by different kinds of movement of the gases within the "air pores".

The capacity for conducting heat can be observed by the usual temperature measurements at varying depths. The temperature gradient between outer air and pile air will probably be influenced by the variations in structure within the pile.

FIGURE I

STRUCTURE REFUSE COMPOST PILES

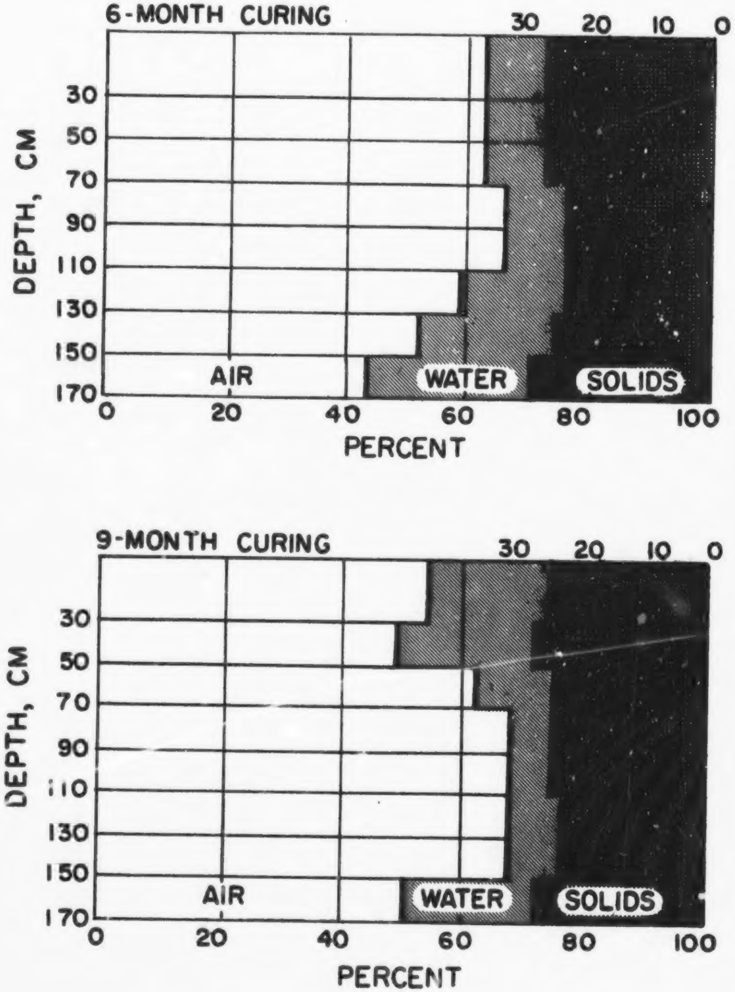
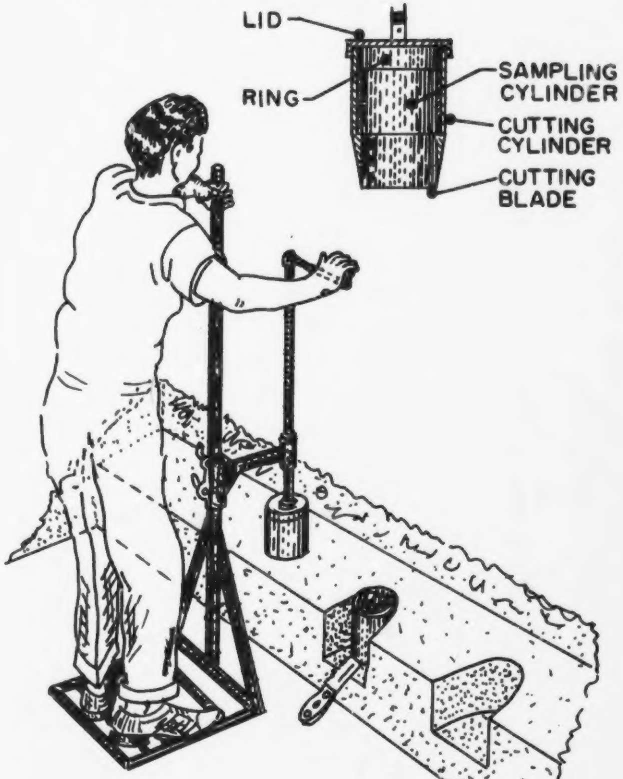


FIGURE 2

SAMPLING COMPOST FOR STRUCTURAL ANALYSIS


LID
RING
SAMPLING CYLINDER
CUTTING CYLINDER
CUTTING BLADE

Optimum water content in the entire cross-section of the pile may be of the first order of importance for controlled decomposition in the compost heap. The structural analysis and the gas analysis show that aerobic decomposition, in the bottom layers and at the water content found, is severely inhibited or even stopped. But in the mid-sections with moisture contents of only about 12% by weight or 25% by volume, sufficient moisture is available only to support special species of xerophilous (dryness-loving) organisms, particularly fungi. For soil organisms the optimum moisture is 70 to 80% of the total water storage capacity (of the soil). The increase in CO_2 in the mid-depths might indicate organism respiration while no increase in CO_2 may be found in the lower damper layers.

Summary

Structural analysis of compost piles with the compressed air pycnometer of von Nitzsch with an apparatus for taking the samples, developed by W. Sauerlandt, yielded definite differences between samples of stable manure composted for two, four, and six months; only slight differences were shown in refuse compost cured for six and nine months but in the eight horizontal layers sampled within the piles there were significant structural differences.

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2. The Boron and Manganese Contents of Refuse and Refuse-Sludge Composts

by P. Keller and R. Halter, Abt. für Müllforschung der Eidg. Anstalt für Wasserversorgung, Abwassereinigung und Gewässerschultz an der ETH, Zürich.

(1) Introduction:

Trace element deficiency diseases in plants in middle and western Europe (humid climate) are caused chiefly by the absence of plant-assimilable boron and manganese in the soil. Availability of both these elements to crops depends strictly on the soil pH and its organic matter content. The solubility, which is closely related to availability for the plants, decreases initially with increasing pH values for both elements, and after passing through a pH range of minimum solubility, again increases. The minimum range for boron lies between pH 7 and 9(1) and for manganese between pH 6 and 8(2). Connection between soil organic matter content and availability of boron and manganese has not yet been completely cleared up. Indications of boron deficiency occur less easily in soils with high humus content than those with low humus content; this is traced to the fact that humus reduces the leaching-out of boron, yet the boron is fixed in a form no longer assimilable by the plants(3). On the other hand, the application of organic matter, especially fresh or decomposing plant waste, to light sandy soils can cause deficiencies in manganese(2). This phenomenon might be due to increased microbial activity in the soil and, thereby, to the precipitation of soluble manganese as MnO_2.

Because refuse and refuse-sludge composts are alkaline due to their high carbonate content and increase soil pH with high application rates, fear was expressed in various quarters that their use would cause boron and manganese deficiency in plants. In other quarters, the idea occurred that hammermilling of refuse containing glass might release boron contained in the glass causing damage to plants sensitive to excess boron. Most important, these hypotheses indicated that the range between deficiency and excess of boron is very narrow.

Only plant research provides a final answer to such a question. Plant research for determination of trace element action, however, is delicate. Also, the results of the experiment have only limited value if one or more factors should change, such as nature of soil, of composts, and of plants being tested. The authors have therefore attempted to determine by chemical analyses the contents of total and plant-assimilable boron and manganese in various composts and to contribute to the solution of these problems.

(2) Materials:

Materials used in the experiments are shown in the first column of table 1 under the five major headings. Source of material is given first by name of city. The following symbols, used in column 1, more completely describe the nature of the materials:

D - Decomposed (or digested, in the case of sludge). Numbers following in parentheses represent length of decomposition time in days.
R - Refuse; S - Sludge; w - Winter; s - Summer
B - Processed in biostabilizer, glass not pulverized.
G - Ground in hammermill, glass pulverized.
F - Fresh or raw (sludge).
(2:1) - Proportion: Refuse to Sludge.
M - Mechanically Thickened (fresh sludge).
A - Air Dried (digested sludge).

Table 1

Boron and Manganese Contents of Refuse and Sludge Composts, and A Few Soils and Glasses, in mg/kg of Dry Weight

Material	Boron			Manganese		
	Total (A)	Active* (B)	(B/A), %	Total (C)	Active (D)	(D/C), %
A. REFUSE COMPOST						
1. Rüschlikon sRBD (ripe)	90	2.5	3.7	505	---	---
2. Uzwil wRGD (45)	115	8.4	7.3	725	13.7	1.9
3. Chur wRBD (ripe)	90	19.7	22.0	625	8.8	1.4
4. Erlangen RD (ripe)	69	8.6	12.5	540	15.9	3.0
5. Lissabon RD (ripe)	35	1.8	5.1	560	43.4	7.8
6. Winterthur wRGD (70)	112	27.7	24.7	636	11.2	1.8
7. Muttenz sRGD (50)	115	13.7	11.9	886	24.5	2.8
8. Havanna RD	179	5.9	3.8	541	12.1	2.2
B. REFUSE-SLUDGE COMPOST						
9. RG FS (2:1)	78	2.4	3.3	630	25.3	4.0
10. RG FS (1:1)	74	2.8	3.8	586	11.0	1.9
11. RB DS (2:1)	27	10.3	38.3	520	105.4	20.3
C. SEWAGE SLUDGE						
12. Winterthur FSM	33	0.9	2.9	360	9.4	2.6
13. Winterthur DSA	30	0.8	2.2	315	10.2	3.2
D. SOIL						
14. Kloten (peat-mineral)	45	0.5	1.1[x]	500	6.3	1.3
15. Reichenried (field soil)	72	0.5	0.7	750	10.2	1.4
E. GLASS						
16. Winterthur (bottles from R)	180	0.6	0.3	---	---	---
17. Jena glass (7± % borax)	18,500	1.2	0.0066	---	---	---

* Active Boron = Plant-assimilable Boron.

x Corrected from original table.

(3) Methods:

a. Total boron: After Prince in Bear, F.E. - Chemistry of the Soil, Reinhold, N.Y., p. 350, 1958.

b. Plant-assimilable boron (hot water-soluble boron): Methodenbuch des Verbandes deutscher landwirtschaftlicher Untersuchungs- und Forschungsanstalten, Vol. 1 (Neumann Publ., Berlin), p. 197.

c. Total manganese: Ibid. p. 72, 82.

d. Active manganese (exchangeable and easily reducable manganese) After Schachtschabel. Ibid. p. 199.

(4) Results:

Table 1 shows the total and plant-assimilable or active boron and manganese contents in the various materials analyzed in mg/kg and the ratio of active to total contents in percent.

(5) Discussion of Results:

(a) General: Average boron content of soils is between 5 and 200 mg/kg and of plant-assimilable boron between 0.05 and 50 mg/kg(3). The minimum content of plant-assimilable boron in the soil, at which no boron deficiency is evident, depends very greatly on the nature of the soil and of the crop; an average value for this content might be 0.5 mg/kg. No dependable average value can be stated for the maximum plant-assimilable boron content that can be tolerated by a given plant without injury. Certain plants, such as lupines, are able to tolerate up to 40 mg/l of boric acid in nutrient solution without injury(4). Plant-assimilable boron may be readily leached out in humid regions so that excess of boron is rare, boron deficiency is common, and certain crops such as sugar beets therefore require regular fertilization with 10-30 kg of borax/hectare.

Soil manganese contents average 100-1500 mg/kg(3). There is no fixed ratio of assimilable: total manganese and active manganese may be insufficient even in the presence of a high total manganese content. Differentiation is made between inactive manganese (completely crystallized or in the form of higher molecular oxides), easily reducible manganese (trivalent or tetraoxides of a lower order), and exchangeable manganese (divalent). Plants can assimilate only the latter. But exchangeable and easily reducible manganese are present in an equilibrium which varies considerably with climate and season. Consequently, the sum of these two values is usually determined and designated as "active" manganese, giving a good indication of the soil manganese requirement(5). Minimum values for active manganese, below which deficiency may occur, lie between 15 and 75 mg/kg. Manganous sulfate ($Mn\ SO_4$) is applied at a rate of 10-15 kg/hectare (3-4 kg of Mn). Damage due to excess of manganese appears only with very high soil manganese content.

(b) Boron Content of Refuse and Sludge Composts: Refuse and refuse-sludge composts contained considerably greater total and assimilable boron than the soil samples examined (this agrees with findings of the Eidg. landwirtschaftlichen Versuchsanstalt Liebefeld of 0.4 mg/kg or more assimilable boron content in well-fertilized soils of the Swiss midlands). The boron comes chiefly from the refuse as refuse composts have generally higher content than refuse-sludge composts and these in turn are higher than sludge alone. (Widespread use of borax washing compounds in Switzerland seems not to influence boron content of sludge.) The consistently high boron content of winter refuse is surprising. (Boron and manganese contents were high in summer refuse composts only in sample 7 from Muttenz. This compost contained a "starter" composed of bacteria and nutrients which possibly contained boron and manganese supplements.) The manganese content of winter refuse is also higher so it is obvious that the difference is caused by the high boron and manganese contents of the ashes. Highest assimilable boron content was shown by sample 6, winter refuse compost from Winterthur, with 28 mg/kg. With an application of 100 tons/hectare of compost containing 40% moisture, the soil would receive 1.68 kg/hectare of plant-assimilable boron (=58 kg borax). This amount is, of course, more than double the usual application of borax; but the 100 tons/ha of compost of high alkalinity from ashes of winter refuse raises the soil pH and fixes boron which, with leaching of soluble boron by rains, need not cause damage due to excess boron. The other composts tested showed lower, but probably sufficient, contents of assimilable boron, compensating for the ability to fix boron by high pH reaction and even preventing occurrence of deficiency in boron-poor soils.

Table 1 clearly shows that pulverizing the glass by hammermilling the refuse has no significant effect on boron content of the compost. Total boron in hammermilled refuse compost (samples 2, 6, and 7) was only slightly higher than that in compost processed in biostabilizers with part of the glass previously removed (samples 1 and 3). The boron content of ordinary glass bottles is very low (sample 16); only heat-resistant glasses, such as Jena and Pyrex glass, occurring in refuse only in small amounts, are made with addition of borax (sample 17).

(c) Manganese Content of Refuse and Sludge Composts: Total manganese in the composts was of the same order of magnitude as in the soils. This is also true for the active manganese content of sewage sludge, but that for refuse and refuse-sludge composts was considerably greater at times than in soils. An application of 100 tons/ha of compost (40% moisture) would add 0.5 to 6 kg/ha of active manganese or within the normal application range for manganese fertilizer addition (4 to 5 kg/ha). This application, however, might still be sufficient to compensate by increasing manganese fixation due to high pH. Plant damage as a result of excess manganese is unlikely.

(6) Conclusions:

Plant damage after use of refuse or refuse-sludge composts due to a deficiency or an excess of boron or manganese is not likely. Only with large yearly compost applications, as in tree nurseries or certain gardening operations, might there be need for caution, especially in the case of winter refuse with its high ash content and pH values. Assimilable boron content of compost is considered a positive factor as it can contribute to the elimination of boron-deficiency in our soils which are usually boron-poor. Composting sludge with refuse, particularly winter refuse, acts not only to balance the contents of the usual nutrients and of humus, but favorably influences the content of trace elements by levelling-out the extremes. Glass pulverization by processing refuse in hammermills has practically no effect on the boron content of a compost.

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3. Urban Refuse for Soil Improvement in Israel by E. Arditti, Chief, Organic Fertilizer Division, Israel Ministry of Agriculture, Haifa

The refuse disposal and utilization problem has recently become of public health importance throughout the world. It has been common in the last century to dispose of refuse haphazardly near the city or even to dump it into rivers (such as Berlin refuse into the Spee). Refuse accumulated near cities constituted insanitation of the worst kind so that, during the first quarter of the century, cities began to change to landfill and incineration, particularly in England and the U.S.A. But inadequacies of both methods soon became evident.

Large areas of land in the vicinity of the city are required for sanitary landfill, not always available. Cities constantly encroach closer and closer to dumpsites as they grow, though dumps were originally far from the limits, and they then have to search for new, more distant sites. It is well-known in Israel that such refuse dumps exist in the vicinity of cities, for example in Chirja and Mikwe. Concerning refuse incineration, this method is expensive, requiring high capital investment as well as operating costs. Under our conditions operating costs are about 8-10 Israeli pounds ($4.45-5.56)/cu m of refuse, or a daily expenditure of 6,000-8,000 pounds ($3336-4448) for refuse incineration in Tel Aviv.

It was clear that in time other solutions would be required and that refuse would be needed for agriculture. The leader in this field was Holland. There a special government office assists cities in constructing plants for conversion of refuse into an organic fertilizer or compost. About 35% of the urban refuse in Holland is so processed and it is hoped that this will increase considerably in the near future. Conditions are similar in Denmark. About 70% of the refuse of large cities in South Africa is already being utilized.

Israel cannot neglect this development, especially because our soils are poor in organic matter and without it we cannot hope to achieve abundant and constant yields. Also the action of chemical fertilizers may be strengthened by the addition of organics without fear of damage due to use of larger amounts of the chemical fertilizers. A further benefit will be better utilization of our precious water through use of organic fertilizers. The agricultural need for fertilizer made from community wastes is particularly urgent because stable manure provides only 60% of the total requirements (2 million cu m) and it is assumed that another 200,000 cu m of refuse compost could be furnished from the cities of Israel. This assumes that all refuse from cities of 10,000 population and over will be used.

Meanwhile, only small amounts of city wastes are being used and this only from a few plants at Tel Aviv, Haifa, and Jerusalem. There the decomposed rubbish from dumps is coarsely screened and then sold to agriculture as compost. About 60,000 cu m were converted in this way last year. The demand was so great that in many cases it became necessary to work the (reclamation) plant in three shifts in order to meet existing orders. Two refuse composting plants now under construction in Tel Aviv and Haifa will begin operation in about 1 1/2 years and the situation should be improved thereafter.

The quality of the composts for agricultural use should, of course, be improved. Minimum physical and chemical requirements of composts, as well as an Analytic and Research Institute, should be established. A "Central Institute of Fertilizers" has been recently set up in the Ministry of Agriculture by the Settlement Division of the Jewish Agency, the Ruppin Agricultural College, the Agricultural Research Station, the Agricultural Center, and the Union of Fertilizer Experts to deal with this entire complex of problems. The last organization has assumed charge of seeing that regular samples are taken and analyzed by standard methods of the Division of Organic Fertilizers, Ministry of Agriculture.

Ten to 15 or more years ago, people were using decomposed refuse in orange groves, particularly around Tel Aviv, without prior screening. They were content to remove only larger materials such as tires, stumps, and the like, and the refuse was loaded by Arab workers onto trucks. Today the technique has considerably improved and refuse from sanitary landfills comprises by far the greatest portion of organic fertilizer used generally in fruit growing and especially in orange groves. It is apparent that the use of compost will become greater with improved quality.

The "byproducts" of refuse composting include a considerable quantity of rags, paper, glass, and other wastes which can be salvaged for our industries or for export.

The need for coordination and close cooperation by various governmental agencies is apparent. The Knesset Commission for Public Service has instructed the Ministry of Health to summon an "Interdepartmental Committee on Refuse Problems." Participation will be from the Ministries of Agriculture, Health, Commerce and Industry, and Interior. Duties of the committee include: examination of existing systems and conditions, testing new systems, and the provision of an information service. The committee will maintain connections with both Israeli and foreign organizations, the first of which will be the IRGR.

Urban refuse (disposal) is an important problem, the satisfaction of which yields double and triple benefits: removal of insanitary conditions, provision of organic matter for agriculture, and provision of raw materials (salvage) for industry. We believe we are on the right track to reach the solution to these problems in time.

4. Composting Refuse by the "Biotank" System. Communication from M. G. Dobrouchkess, Paris, French Representative of IRGR.

(1) General:

The "biotank" system has two objectives:

a. To guarantee refuse disposal in a sanitary manner, including the composting process and the final compost.

b. To compost so that costs are within the budget of the city.

The biotank system does these things and produces a relatively high-value compost. The system further attempts to reduce the traditional elements of a cell-type composting plant by omitting the decomposition cells of reinforced concrete normally used yet providing for construction and operation to meet the requirements. The compost quality is similar to that of stable manure and has a uniform granular structure, readily applicable to crops. It is odorless, free from weed seeds, and its nutrient content exceeds that of horse manure. The market value is such that sales should more or less cover operating costs.

(2) Plant Description:

The plant has two parts: the refuse processing in a single building, and the fermentation chamber in which decomposition occurs in a windrow and which is movable along the windrow axis.

Trucks discharge refuse into a hopper in a room which is kept under negative pressure to avoid escape of dust. A travelling grab raises the refuse to a hopper. The refuse drops into a rotating drum screen which sieves it into three fractions: a) fines going directly to the biotank,

b) middlings comprising the bulk of the compostable materials, and c) oversize consisting primarily of large boxes, tires, etc. unsuitable for composting. The middlings pass through a magnetic drum separator and then to a hammermill, after which they are recycled to the screen until reduced to fines. The plant is so automated that only one worker is required (the grab crane operator).

The piling site is a rectangle similar to a stretch of street the width of which is dependent upon the plant capacity and the length upon the compost storage capacity. The biotank is movable on rails which are on low walls running the length of the rectangle. Also along the (center of) the rectangle are semicircular, perforated pipes (manifold) which make possible mechanical aeration of the compost heaps.

The biotank provides two functions: forming and storing the compost windrow, and fermenting the compost in a closed chamber. (Processed) refuse is fed from above into the biotank and formed into a semicircular windrow of uniform size. When the pile is of desired height, the biotank is slowly moved forward. The windrowed material remains 12 to 18 days in the fermentation chamber during which it is aerated through the perforated pipe and is periodically moistened. Temperatures of up to 70 or 80°C develop within the windrow, thus killing the pathogens and weed seeds. After the 12- to 18-day composting, the biotank passes beyond the windrow and the compost may be distributed immediately to the consumers. The compost is odorless and its use presents no hazards. One laborer operates the biotank, supervizing the windrow-forming and moving the biotank forward with the help of an electric motor.

A composting plant of the biotank system was placed in operation for the City of Calais in May 1958 and data on it are as follows:

Refuse processed per day (8 hours) - - - -	80 metric tons
Compost produced daily - - - - - - - - - - -	12 to 22 tons
Operating force - - - - - - - - - - - - - - -	2 laborers
Maintenance force (4 hrs/day each) - - -	1 mechanic 1 assistant
Electric energy/ton compost - - - - - - - -	5 kw (winter) 6 kw (summer)
Processing and composting cost/ton of refuse - - - - - - - - - - - - - - - - - -	280-300 francs ($0.56-0.60)
Average proportion of materials from refuse:	
Compostable refuse - - - - - - - - - - -	80%
Scrap iron - - - - - - - - - - - - - - - -	1.5-2%
Discard and salvage- - - - - - - - - - -	10%
Sale price of compost/ton - - - - - - - - -	1000 francs ($2.00)

The plant is operated by the Public Service of the City of Calais under the Director of Public Works.

(Ed. note: The windrow at the Calais plant is formed in a large circle by discharge of processed refuse from a pivoting belt conveyor, not in a "rectangle" as described above. The "biotank" is not a tank but a movable windrow shelter and the "biotank system" is more aptly described as sheltered, forced-air windrow composting. The compost is not turned during decomposition but may be cured in the same windrow behind the shelter. Although operating costs here reported are quite low, capital costs for the Calais plant were high --- about $10.15/cap. served or $9,227/ton, rated daily capacity of refuse).

5. News Briefs

a. Japan:

The "ichikawa" refuse composting plant of the city of Himeji was dedicated in the presence of the Mayor, representatives of various Ministries, and numerous members of Parliament on April 5, 1959. It is a Dano biostabilizer plant (Dano Machine Corp., Copenhagen). While formerly odors and nuisances developed at the refuse dump, now the refuse processing occurs in a sanitary manner. The plant processes 30 tons/day of refuse into 15-20 tons of compost which is routinely tested by the Japanese Fertilizer Control Institute. Agriculture urgently needs compost. It contains an average of 0.6% nitrogen, 0.3% phosphate, and 0.5% potassium.

b. Holland:

The city of Maastricht (90,000 population), in the extreme south of the Netherlands, placed in operation a Dano egsetor plant in 1959. The compost sells not only in the vicinity of the city but in adjoining areas in Belgium where there is a very great interest in compost.

The city of Deventer (55,000 pop.) also placed in operation a new composting plant (Dorr-Oliver rasping system) at the end of 1959. The plant produces compost for field crops or fine compost for truck gardening, according to the needs. The refuse is freed from shards by means of a roller crusher and ballistic separator. The V.A.M. (Refuse Disposal Company) has the option to sell the total compost output. This is the thirteenth modern composting plant built in the Netherlands since 1951. The fourteenth will be completed in the city of Arnhem at the end of 1960.

Demand for compost in the Netherlands has increased recently to such an extent that at the beginning of the year almost all compost plants were sold out for the first half of the year. This is because the dry summer of 1959 forced farmers to use more manure than in normal years in order to maintain fields in good condition. Thus, much less stable manure was sold by the farmers. Another probable reason for the increased demand is that farmers and horticulturists are more aware that Dutch soils show an urgent need for organic fertilizers, moreso because, with progressive mechanization of farm operations, less manure is yielded and soil structure becomes poorer.

The compost plant at Mierlo near Eindhoven (van Maanen system) operated at full capacity for the first time in 1959. A total of 53,000 tons of compost was produced, compared to 37,000 tons in 1958 and 4,370 tons in the initial year of operation, 1955. Demand for compost also increased with the rise in production. To satisfy an increasing demand for high quality compost for gardening, a shard-free compost is now being processed by means of a special grinder designed for that purpose. It is remarkable that compost is fostered not only by farmers and gardeners but also by communities and private concerns.

c. Italy:

In 1959 the city of Udine built a Dano biostabilizer plant for processing refuse from 85,000 population. It is already serving 80,000. The plant treats domestic refuse, street sweepings, market refuse, and (other) organic refuse. Raw refuse amounts to 720 cu m or 200 tons per week. The materials are well-suited for composting, having little paper and scrap (2%) and much fruit and vegetable waste. The receiving pit capacity is 60 cu m and it is provided with double folding doors. Conveying is by completely covered belts within the building, eliminating the dust problem. The personnel (2 men) do not usually come in contact with the refuse. The scrap iron baler is even automatic. Retention time in the biostabilizer is now 3½ days. Screen residues are divided into heavy mineral components which are dumped in the open and light organic components which are again passed through the biostabilizer. In August-September successful performance trials were made. Complete construction costs of the plant amounted to scarcely 700,000 Swiss francs ($161,000).

Near Udine refuse has been composted in a primitive manner since ancient times because the soil is poor in humus. Compost sale will offer no difficulties, particularly because the product is now more attractive.

The "Fertilia" Company of Mailand built a new Earp-Thomas type plant in Verona in 1959. Part of the refuse from Verona (about 50 tons per day) is processed. The Fertilia Company also handles compost sales.

d. Mexico:

The company "Fertilisantes Organicos de Mexico, S.A. (Mexico City) has installed a composting plant of the Earp-Thomas process in the city of Aguas Calientes which processes 25 tons of refuse per day.

e. Switzerland:

The Refuse Disposal Cooperative of Baden-Brugg, which also includes the communities of Ennetbaden, Wettingen, Turgi, Windisch, Killwangen, Obersiggenthal, and Neuenhof, has decided to build a composting plant of the SMG-process (Schweiz. Metallurg. Gesellschaft and Multibacto, Basel). In the first stage the plant will process up to 50 tons/day of raw refuse, in the second up to 100 tons/day. The second stage will also process sewage sludge.

The Küsnacht (Zürich Canton) community has decided to expand its present Dano egsetor plant by installing a coarse and a fine Bühler hammermill in order to reduce the shards, pottery fragments, etc. which amount to that in normal refuse. Recently sludge has also been mixed with the refuse in the egsetor.

6. Discussion Corner (The Editor assumes no responsibility)

a. Rebuttal of Dr. E. O. Riedel, Gruiten, to criticism of Dipl. Engr. H. Naef ("Is the Refuse Typhoon Suitable for Swiss Conditions?"), Information Bulletin No. 6.

I should like to define my position on this criticism as follows:

(1) Of course the calculations of my critic as well as my own are based on the sale of all of the compost produced.

(2) Not one sentence of mine indicated that small communities of 1,000 population and medium-sized cities of about 10,000 are suitably served by this process. Consequently, not only the premises but also all conclusions based on this numerical criticism are invalid because they are based on unrestrained assumptions not well-grounded. Self-selected presumptions are untenable.

(3) Under Swiss conditions not only are 8 Swiss francs ($1.85)/cu m realized, but often considerably more.

(4) If three turnings of the compost are favored, which has to be pegged at 2.65 Sw. francs ($0.61), then this operation must be done by antiquated methods and out-of-date machines. Simple modern machines require only five minutes of working time per cu m. Therefore, not more than 1 Sw. franc ($0.23)/cu m should be alloted to turning.

(5) Modern hammermills produce a largely homogeneous, well-aerated, ground material from urban refuse and two turnings suffice.

(6) As to the contention that, even with a small machine at half price, operating costs of the same magnitude are required, no proof has been shown.

(7) a. Comparison between a mobile plant for 10,000 population and a fixed plant for 25,000 is arbitrary and unjustified. Does the operation stop when the worker is ill or on vacation?

b. Estimated transportation cost for raw refuse, at least triple in volume, is false. It is precisely the advantage of the mobile plant that it can go to the local collection point, while, in the case of the fixed plant, the triple volume has to be transported to a central location.

(8) If only two factors for the stationary plant are correctly applied then labor costs are 24,000 Sw. francs ($5,500)--hauling costs of the raw refuse are 9,000 Sw. francs ($2,070). These show a total expenditure

of 97,000 Sw. francs ($22,300) for the fixed plant--83,000 ($19,100) for the refuse typhoon--and a net expenditure of 70,000 Sw. francs ($16,100)--53,000 ($12,200) for the refuse typhoon.

(9) The objection that the mobile plant is only a prototype while the stationary plant has been tested and tried has been a standard objection to each progressive discovery since the invention of the steam engine. All discoveries, even those of my critics, were once hypotheses.

(10) The plans of operation of a fixed plant and of the refuse typhoon are understandably different. The assumption of deposits up to a week is seized from the air. Also, it is possible with the refuse typhoon to process refuse directly from the trucks at any time.

(11) The assumption that a mobile plant might be difficult to keep in operation while a stationary plant is in operation even during the time of transportation of the refuse is based upon a false conclusion. It is probably presumed that the collection trucks are present and active; but it cannot be supposed that the refuse typhoon would stop operating when the refuse arrives. The refuse typhoon is moved essentially outside the normal work hours by a separate service force (comparable to the plant of my critic that is provided with only one operating force).

(12) Even the stationary plant feels the effect of the weather because there too, after the processing, refuse is piled in the open. If the danger of anaerobic decomposition exists, then it exists for both methods.

(13) In point 4 my critic expresses great skepticism concerning the rotary pickup apparatus I provided. I want to acquaint my critic with the fact that one of these plants has been operating satisfactorily on the refuse in Stuttgart (those distinguished experts of Stuttgart) for more than five years!

(14) The heart of the plant, the Novorotor (a Swiss invention), has demonstrated that pre-sorting is unnecessary. The operation therefore dispenses with manual labor and correspondingly improves hygienic conditions. No statement can be made about capacity limit as practical experiments have revealed a performance reserve of about 80% over that stated in my article.

(15) Concerning Swiss legal restrictions relating to driving it in traffic, this point can be settled by an agreement with the officials.

(16) The title of the criticism "Is the refuse typhoon suitable for Swiss conditions?" is misleading because the general operating ability of the machine--not merely under Swiss conditions--has been questioned.

7. Literature

a. Mr. B. Frechen, City of Duisburg, has kindly translated for the Information Bulletin abstracts from the 1959 issues of "Mededelingenblad von de N.V. Vuilafvoer Maatschappij V.A.M." into German.

Volume 14, 1959:

Number 1, February:

Recent agricultural investigations have revealed that optimum crop growth depends greatly on the proper water retention in the soil and that the moisture requirements for any type of soil can be met by irrigation or better by raising or lowering ground water levels to provide optimum conditions.

An experiment with various bedding materials in chicken houses indicated better results with refuse compost than with peat moss, wood shavings, or rye straw.

Number 2, April:

It is alleged that applications of compost to pastures assist in control of hoof and mouth disease. The compost promotes growth of clover and its higher Ca and Mg and lower K content provides the cattle with the required resistance against the illness.

There is a report on composting in Hungary and East Germany. After the war in Hungary the use of refuse of all types took and unusual upswing and, by 1957, 50 plants were in operation with a yearly production of over 1 million tons of compost. Composting has also become significant in East Germany. Special attention is being devoted to prefermentation of cattle feed--spontaneous heating and fungi (mold) production.

Field experiments with synthetic fertilizers gave 15% greater yields upon additional application of organic fertilizer, 39% upon additional irrigation, and 54% with additional applications of both organic fertilizer and irrigation.

Number 3, June:

Repeated tests show that pigs prefer to root in compost and even eat it without injury.

Frequent reports show success in increasing the effect of fertilization by the use of compost in raising beef cattle.

References are made to the papers presented at the IRGR Congress at Scheveningen (see: Info. Bull. No. 7).

Number 4, August:

The Compost Foundation (Stichting "Compost"), Jac. Obrechtstraat 63, Amsterdam, has a collection of 50 colored slides for teaching farmers and gardeners about production and use of refuse compost. A few sets are still available for 50 guilders ($13.40).

In northern Belgium a large stretch of fine sandy soil was stabilized by windbreaks, treated with 30 tons/ha of compost, and seeded with grass.

Number 5, October:

The view of Prof. Barbier of France that use of artificial fertilizers and other measures have increased the organic content of the soil yearly inasmuch as the fertilizers increase root growth and stubble residues remaining after harvest, is objected to because this is not the case, for example, with marsh areas. Increased application of artificial fertilizers as a rule presupposes an increase in soil organic matter.

Formation of antibiotics in the soil has been given special attention recently. Should they be formed by use of simple measures, new possibilities for controlling plant diseases would be reached. Compost, with its abundant microbial flora, would then assume greater importance.

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*These papers may be obtained from: The Secretariat, IRGR, Physikstrasse 5, Zürich 7/44, so long as they last. (NOT available at USPHS, Savannah).

+These papers may be obtained from: U.S. Public Health Service, Tech. Develop. Labs., Box 769, Savannah, so long as they last. (NOT available at IRGR, Zürich).

INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)

Information Bulletin No. 9

September 1960

1. The Reclamation of Refuse at Budapest by Náray Dezső and Tóth Jenő, Municipal Sanitation Office, Budapest.

One of the most important problems of public health is the satisfactory removal, disposal, destruction, or reclamation of the large quantities of domestic refuse, street sweepings, and market wastes from cities. Individual solutions to the problem vary in different countries according to local conditions, the type of wastes, and the demands regarding utilization. Refuse treatment has been basically altered in Budapest. Before deciding on the method of refuse treatment, we conducted extensive experiments with modern techniques and processes to adapt them to Hungarian conditions.

The quality and quantity variations in Budapest refuse were investigated by seasons. Although refuse quantities are highest during the winter months due to the accumulation of ashes, quantities are equally as great on many a summer day because of the high yield of fruit and vegetable wastes.

Systematic analyses of Budapest refuse resulted in the following average chemical and mechanical composition:

Chemical Analysis, Percent

	Moisture	Ash	Organic Matter	Organic Matter, Dry Basis
January	10	70	20	22
May	44	26	30	54
September	70	10	20	66

Mechanical Analysis, Percent

	Winter Refuse	Summer Refuse
Under 4 mm	35	5-10
4-15 mm	25	10
15-20 mm	15	10
Over 20 mm	25	70-75

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Composition of Individual Mechanical Fractions, Percent

		Moisture	Ash	Organic Matter	Organic Matter, Dry Basis
Winter Refuse	Under 4 mm	5	80	15	16.0
	4-15 mm	7	75	17	18.3
	15-20 mm	9	72	19	20.8
	Over 20 mm	15	60	25	29.4
Summer Refuse	Under 4 mm	20	66	14	17.5
	4-15 mm	24	56	20	26.3
	15-20 mm	37	41	22	35.0
	Over 20 mm	56	17	27	61.4

Inorganic nutrient contents are important for utilization of refuse in agriculture. These contents varied by size between the following average values (calculated by dry weight):

Nitrogen: 0.8 - 1.2%
Calcium as CaO: 5 - 7%
Magnesium as Mg O: 1 - 2%
Potassium as K_2O: 0.8 - 1.0%
Phosphorus as P_2O_5: 0.4 - 0.6%

The carbon-nitrogen ratio (C/N), important in the composting process, was 25-35 in the raw refuse, which is to be considered favorable.

We also determined the salvable content of the refuse simultaneously with the mechanical analysis. The values were independent of the season:

Stone, glass, and ceramics: 5 - 7%
Paper: 2 - 5%
Rags: 0 - 0.5%
Bones: 1 - 1.5%
Metals: 1 - 2%

The density of the refuse averaged 400 kg./cu.m. in summer and 600 kg./cu.m. in winter.

Qualitative and quantitative analyses of the refuse from Budapest are being continued. Extensive practical experiments are also being conducted regarding the disposal and utilization of refuse. Two disposal processes were considered -- incineration and controlled dumping on wastelands. We decided against incineration for the following reasons:

1. Budapest summer refuse with its high moisture content and winter refuse with its high ash content cannot be burned without auxiliary fuel because the average heat content is only 600 Kcal/kg.

2. The fine ash content of the refuse and the large amount of ashes and clinkers after combustion, particularly in winter, create serious haul problems.

3. Construction and operation of refuse incinerators result in large investments that are difficult to amortize, as foreign experiences have adequately shown.

4. The need for humus, to replenish soil humus losses due to intensive cultivation, is particularly important because insufficient stable manure is available. Compost, particularly that made from summer refuse, has a high organic content of agricultural origin.

After deciding against refuse incineration, we disposed of the refuse temporarily by means of controlled dumping. Large pits or swales were filled with refuse in a sanitary manner. The dumping sites were located near to refuse collection districts to insure optimum collection fleet use and low-cost hauling. This method proved to be very good in Budapest and areas were used which are now suitable for urban parks and playgrounds. We succeeded in preventing slides, on a slope with sliding tendency, by dumping prismatic piles of refuse side by side and in layers.

Despite these good results, we believe that dumping is not the ideal solution to the refuse problem as it destroys refuse materials that are indispensable to agriculture. The problem therefore shifted from destruction to reclamation of refuse by composting.

The decisive argument for refuse composting is that agricultural development depends on the greatest possible increase in soil fertility. The soil organic matter, its quality and maintenance, exert a strong influence on development of soil fertility. Mineral fertilizers can only replace nutrients taken from the soil by plants - N, P, and K. They determine the chemical fertility of the soil, the N-P-K level. But they do not insure the physical fertility of the soil for crops. Temporary larger yields can, of course, be achieved by increased use of mineral fertilizers; sooner or later, excessive use of mineral fertilizers reduces soil fertility or even destroys it entirely.

Soil fertility can only be maintained or increased through adequate application of organic fertilizers such as stable manure, green manures, or compost.

Highly organic industrial wastes attain very minor usage in Hungary, although canning, meat and poultry, leather, and various food and agricultural wastes could produce large amounts of compost for agriculture. Also, sewage sludge, with a nitrogen content of 1.3 percent in the digested sludge from the Budapest secondary treatment plant, can be added either raw or digested as a supplement to compost. Another larger source of raw material for compost consists of the manure from cattle-feeding. Although part remains on the soil, the bulk is burned and thus lost to the soil.

In our experiments with composting, we studied the decomposition factors, the required minimum organic content in the raw materials, the effect of microbial inoculation, the course of temperature in the piles, the influence of pH, and the degree of aeration. The decomposition of the material during composting is shown in the following table:

	Moisture Content	Dry Matter	Ash	Organic Matter	Carbon	Nitrogen	C/N
	Percent, Wet Basis:-						
Initial	51.9	48.1	21.5	26.6	13.8	0.38	36.0
18-day	44.3	55.7	31.4	24.3	12.6	0.51	24.7
40-day	40.2	59.8	37.5	22.3	11.5	0.6	19.4
			Calculated Percent, Dry Basis:-				
Initial			44.7*	55.3*	28.7*	0.79*	36.0
18-day			56.3	43.7	22.7	0.92*	24.7
40-day			62.6	37.4	19.4	1.01	19.4

(*These values have been re-calculated from those given in the German and French versions because of obvious errors.--Ed. note)

These data relate to domestic refuse processed during September in experimental Beccari cells without turning. The table shows the increase in ash content, decrease in organic matter, and changes in C/N. The loss in organic matter on a dry basis was only 14 percent because of optimal conditions; greater losses occur with inadequate aeration. Contents of P_2O_5 and K_2O remained essentially the same during processing at 0.47 and 0.86 percent (dry basis). Reducing the initial C/N could speed up composting; e.g. addition of slaughterhouse wastes, horns and hoofs, leather wastes, settled sludge, etc. C/N may also be easily lowered by adding ammonium salts, but it should not be reduced below 10, the preferred value being about 30. Increasing N, P, and K during composting, instead of on the fields, would achieve better yields in our opinion.

Compost should not be judged on the basis of its N-P-K content as it is primarily a means of soil improvement regarding physical structure, humus content, and trace elements. The N-P-K content can and should be adjusted to optimum levels with mineral fertilizers.

The following table shows the components of composts of several types and degrees of decomposition:

	1	2	3	4	5	6
	Percent soluble in:					
Water	3.8	7.9	3.0	5.2	5.4	3.0
Alkali	6.9	4.4	1.0	0.7	0.4	1.6
Hydrochloric acid	14.2	11.5	11.0	6.9	9.8	19.5
Sulfuric acid	22.0	19.9	18.0	9.6	14.3	28.8
Total Organic Matter	24.9	26.9	14.7	32.2	34.4	27.4

Sample 1:	Summer refuse compost of good quality, with good aeration.
Sample 2:	The same compost, without aeration.
Sample 3:	Spring refuse, without good aeration.
Sample 4:	Winter refuse.
Sample 5:	Refuse, dumped 15-20 years ago.
Sample 6:	Residue from summer refuse from a biogas plant.

The components soluble in the various solvents differ according to the compost type, maturity, and quality. Composting reduces cellulose, hemicellulose, and pentosans, while lignin accumulates. But anaerobic decomposition leaves cellulose, hemicellulose, and other resistant organic substances. In composts such as 4 and 5, carbon remains in unavailable form.

Bacteriological studies were also made using slide cultures to determine total counts and various staining methods to differentiate living and dead cells. Results were unsatisfactory because of the multiplicity of the microflora so we attempted to determine microbial activity by variations in the carbon dioxide yielded.

The following procedure was used: a carefully weighed amount of compost and a measured amount of alkali of known titer were placed in an Erlenmeyer flask which was sealed airtight and stored in an incubator at 28-30° C. The alkali was renewed every 4 days at which time the CO_2 was determined by titration. This showed that half-ripe compost produced 180 mg. CO_2/g., in 4 days in contrast to summer refuse, well-aerated many times, which produced 90 mg. CO_2. A poorly aerated spring compost yielded 60 mg.; a winter compost produced 40 mg. CO_2. This method shows differences in composts of different origins but it is not suitable for plant operation checks because it is too tedious and complicated.

Total counts of microorganisms in aqueous suspensions are shown in the following table:

Compost Type	Total Count/Gram
Wet, half-ripe, summer refuse compost	10^{10}
Dry, half-ripe, summer refuse compost	10^8
Composted street sweepings	10^7
Composted winter refuse	10^6
Mature compost, screened	10^7

No phages or coliform bacteria were found in well-matured compost. The importance of aerobic composting cannot be sufficiently stressed.

Anaerobic digestion with gas production was also considered. There are fewer reports in the literature on anaerobic than on aerobic decomposition. That large-scale plants exist for composting and not for anaerobic fermentation indicates the former to be more promising, economical, and offering easier use of the end product. Yet anaerobic methods offer better exploitation of the organic wastes, principally by producing methane with a heating value of 5-6,000 calories instead of heat as produced by aerobic composting. The end products of the two methods have about the same fertilizing value. Technical difficulties prevent widespread use of anaerobic processes, particularly in mechanical agitation and in maintaining the necessary 25-30° C. temperatures.

Both wet and dry (anaerobic) processes are available. In the wet process large amounts of material can be fairly well agitated and fermented but the large mass makes heating difficult and requires high capital costs. The dry process is considerably simpler and may also be used for small plants.

We conducted laboratory and pilot-plant studies on this process, using first fresh, ground and unground, market wastes and garbage, and then unground, previously composted garbage. In laboratory studies 200 g. of material were fermented at 32-34° C. (incubator) and the speed of gas production, composition of gases, and chemical changes in the refuse were determined. During a 40-day fermentation, 200 to 300 cu. cm. of gas (6000 cal)/g. of organic matter was produced.

Pilot-plant experiments were conducted in sealed iron tanks of 900 l. placed in a Beccari chamber filled with decomposing refuse. Mixed amounts of 300 kg. of garbage and 100 kg. of sludge at 25-30° C. produced 17 cu. m. of gas/mo. with a methane content of 45 to 50 percent. Constant temperature was produced by the aerobic refuse compost in the Beccari cell, surrounding the iron tanks. The fermentation speed depends largely on the temperature. Required temperatures for complete fermentation were 4 to 5 days at 45-50° C.; 30 to 40 days at 20-30° C.; and 70 to 80 days at 10-15° C.

Heating the refuse on a large scale would be economical only by the biochemical method described. Such costs would be low, and servicing is simple. From 10 tons of refuse with 20 percent dry matter, 500-600 cu. m. of gas, or about 200 cu. cm./g. of organic matter, can be obtained. Fermentation of summer refuse with its high cellulose content should be studied. The gas is of interest because of its heat content and the residue may be valuable as a fertilizer with the following composition:

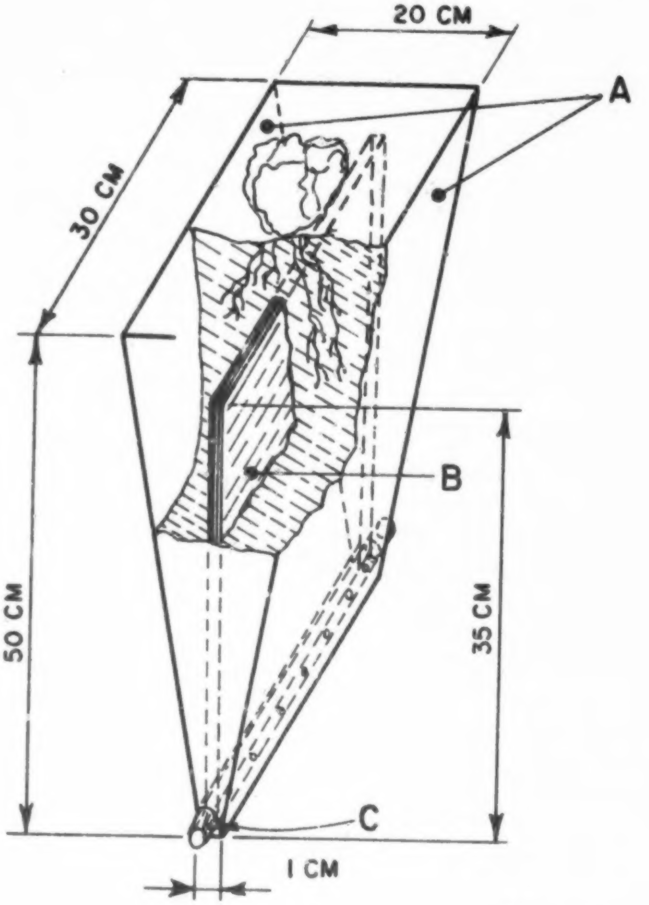
48% Moisture
45% Organic matter (dry basis)
65% Ash (dry basis)
1.1% Nitrogen (dry basis)
C/N: 17

These are the problems of the reclamation of refuse at Budapest. The studies are incomplete and should be supplemented with reference to the utilization and reclamation of the end product, compost. This requires agricultural research and we are conducting such trials using various plants and different composts on fields, including hotbed trials (compost as a heat source). We hope to confirm our conviction that reclamation of refuse is indispensable and of great importance in agricultural uses.

2. The Effect of Urban Refuse on Root Growth by Engineer B. Teensma, Amsterdam.
(Abstract from "Mededelingenblad", V.A.M., Amsterdam, Vol. 15, No. 3.)

It has been repeatedly observed in practice that refuse compost stimulates root growth. In 1958 our attention was called to a method used

FIG. 1: ROOTING BOX


20 CM
A
30 CM
B
50 CM
35 CM
C
1 CM

A-GLASS WALL COVERED WITH A HINGED LID.

B-DIVIDING WALL

C-OUTLET TUBE

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at the "Institut für Kulturtechnik und Wasserhaushalt des Bodens", Wageningen, the Netherlands, which permits following root growth under various conditions and to record it photographically.

It utilizes a small box (a rooting box) about 30 x 20 x 50 cm. high. The walls are sloped towards each other being only 1 cm. apart at the bottom (see figure 1). The box may be divided in two equal parts by a longitudinal wall which is 35 cm. high, not reaching the top of the box. The two sloping sidewalls are of glass. The box is covered with a removable wooden lid, as the roots must sprout in darkness.

The box is filled with soil from above. In our trials, half was treated with commercial fertilizer (N, P, K) and the other half received refuse compost and the same mixture of fertilizer. A series of plants were sown or set out above the dividing wall. Root growth was observed through the glass walls to see in which side better conditions existed. We used barley, English rye grass (Lolium perenne), rye, spinach, radishes, beets, red clover, lettuce, tomatoes, and tulips. Root formation was considerably better in the side with compost (about 75 tons/hectare) than in the half without compost, without exception. The use of rooting boxes for observing and recording root growth is convincing. Trials with these boxes are continuing and many organic fertilizers are being compared in regard to their influence on root growth.

Figure 2 (which is not reproducible) showed 4 pictures, each with and without compost, of root growth of English rye grass, spinach, barley, and red clover.

3. Oxygen Consumption and Respiratory Quotients in the Aerobic Decomposition of Synthetic Garbage, by K. L. Schulze, Department of Civil Engineering, Michigan State University.
(Abstract from: "Proceedings 13th Industrial Waste Conference, Purdue University, pp. 541-54, May 1958 [published 1959].)

Experiments with synthetic garbage were carried out in a horizontal rotating drum of about 20 l. capacity in which aeration was provided. The garbage was composed as follows:

Bread	1.5 kg.	Oranges	2.0 kg.
Potatoes	2.5 kg.	Vegetables (beets, celery, lettuce)	2.5 kg.
Apples	2.5 kg.		
Meat	0.5 kg.	Coffee grounds	0.25 kg.
Newspaper	1.5 kg.		

Outlet air was analyzed for O_2 and CO_2 and the inlet air was regulated so that the discharged air contained a minimum of 2 to 5 percent O_2. The respiratory quotient (RQ = vol. CO_2/vol. O_2) was calculated: percent CO_2 in outlet air/21-percent O_2 in outlet air. The garbage was ground to pass a 1.2 cm. sieve and its moisture content of 68-71 percent was reduced to 50-60 percent before being composted. The following changes took place:

Moisture content: +12.5%
N content: increased 1.9 to 2.7% (caused by loss of weight during composting).
Organic matter: decreased from 94.2 to 90.8%.
C/N: decreased from 28.6 to 19.9%.
pH: increased from 5.2 to 8.8

Loss of weight:	Organic matter:	40.1%
	Dry weight:	37.6%
	Nitrogen:	10.2%

Oxygen consumption, calculated as mg. O_2/g. original organic matter/hr., varied between 1 and 5 mg. In the thermophilic range, the oxygen consumption, and therefore the destruction of organic matter, was greater than in the mesophilic range. About 40 to 60 l. O_2/day/kg. original organic matter had to be supplied during the period of greatest decomposition.

The respiratory quotients varied between 0.8 and 0.9, agreeing with values found by Wiley.

4. Erosion Prevention with Compost in Viniculture, by Agr. Engr. E. Peyer, Federal Research Institute, Wädenswil.
(From Schweiz. Zeitschr. f. Obst-u. Weinbau, No. 5, 1960.)

In our article "Research on prevention of erosion damage in viniculture and its measurement" (Schweiz, Zeitschr. f. Obst- u. Weinbau, pp. 597-603, 1958), we showed, by large-scale experiments on a steep slope at Eglisau, that use of urban refuse compost greatly reduced erosion damage in viniculture. We could not follow up these results of 1958 because in 1959 no summer erosion damage occurred on the slopes in Eglisau.

Similar experiments were conducted at two other places, without as precise erosion measurements as at Eglisau, are briefly presented.

1. The Leutschen Experiment.

"The Foundations Union" owns about 20 ares in the Leutschen vineyards of mother garden which is ordinarily cultivated. Very severe erosion damage appeared year after year in this mother garden. This resulted in large loss of fine soil and in considerable expense to eliminate erosion damage. Encouraged by the Eglisau results, we decided to introduce compost to these plots to stop erosion damage. The entire plot required 2 cu.m. of urban refuse compost/are. (100 sq.m.). The Dano plant at Küsnacht-Zürich supplied free compost for the experiment for which we thank those responsible.

The following applies to transportation and spreading of compost by common labor:

Transportation: Compost was hauled from Küsnacht in 4-8 cu.m. and 2-9 cu.m. trucks to Leutschen. It was hauled the last 200 m. by tractor and sled. Haul costs were 229 Sw. Fr. or 4.58 Sw. Fr. ($1.15)/cu.m. of compost.

Spreading: On frozen soil, this required 22.5 hrs. with a tractor and windless and three men, amounting to 275.60 Sw. Fr. The 24.3 are plot received 2 cwm./are. Total cost was therefore 20.76 Sw. Fr. ($5.19)/are. Spreading costs were 5.51Sw. Fr. ($1.38)/cu.m.; hauling and spreading amounted to 10.09 Sw. Fr. ($2.53)/cu.m.

Fifty cubic meters were spread over 24.3 ares. One cubic meter of compost weighed 720 kg.; thus about 1440 kg./are were applied. Two heavy deluges were recorded at Leutschen during the summer of 1959, causing severe damage in part of the vineyards of the monastery. The mother garden, treated with compost, showed usually no evidence of erosion in contrast to earlier experiences. Results were therefore good and, moreover, the quality of the soil was improved by the compost. Crust formation, frequently observed formerly, did not appear on the surface of the plot. A disadvantage of the compost was the heavy weed infestation, mostly tomato plants. (The compost was perhaps too little decomposed - /Zürich/ Ed. note.)

2. The Sternenhalde Experiments.

Similar observations were made at the vineyards of the Research Institute at Wädenswil on the Sternenhalde, testing "Bactomull" compost, produced by the Multibacto Company, on a cultivated plot on a steep slope. On the vineyard ridge 5 kg. compost/sq.m. was spread and lightly hoed in. During summer storms, which caused severe damage to other plots, no erosion pits or gullies appeared on the treated surfaces. Even in (previously) eroded pits, no fine soil was evident, in contrast to the untreated slopes. Good results were therefore accomplished by compost use to prevent erosion damage. Sufficient compost must be applied, however, because erosion damage was observed after an application of only 2 kg./sq.m. in another plot.

Use of compost is particularly recommended on steep slopes, where erosion danger is greatest. Requisite for the large compost usage are low cost compost and small transportation and distribution costs.

5. Composting Urban Refuse with Various Additives by Mr. O. Horstmann, Supt., Heidelberg Compost Plant, and Dr. H. Sachsse. (Abstracted from a working report of the Heidelberg plant.)

Experiments were set up in 1957 at the Heidelberg composting plant to determine if decomposition of urban refuse from the Dorr-Oliver rasping machine (Refuse Treator) could be influenced by the admixture of partly ripe or mature summer or winter compost or stable manure. Composting was conducted in six experimental piles of about 15 cu.m. volume and measuring 4 x 3 x 1.5 m. Comparative analyses and evaluations of the compost were made by the usual test methods. Ground summer refuse, collected in August, was used.

The piles had the following composition:

1. 80% ground refuse, 20% cow manure.
2. 100% ground refuse.
3. 90% ground refuse, 10% mature summer compost, about 9 mos. old.
4. 70% ground refuse, 30% mature summer compost, as in pile 3.
5. 80% ground refuse, 20% winter compost, about 1/2 year old, with 50-60% ashes.
6. 80% ground refuse, 20% immature summer compost, 14 weeks old.

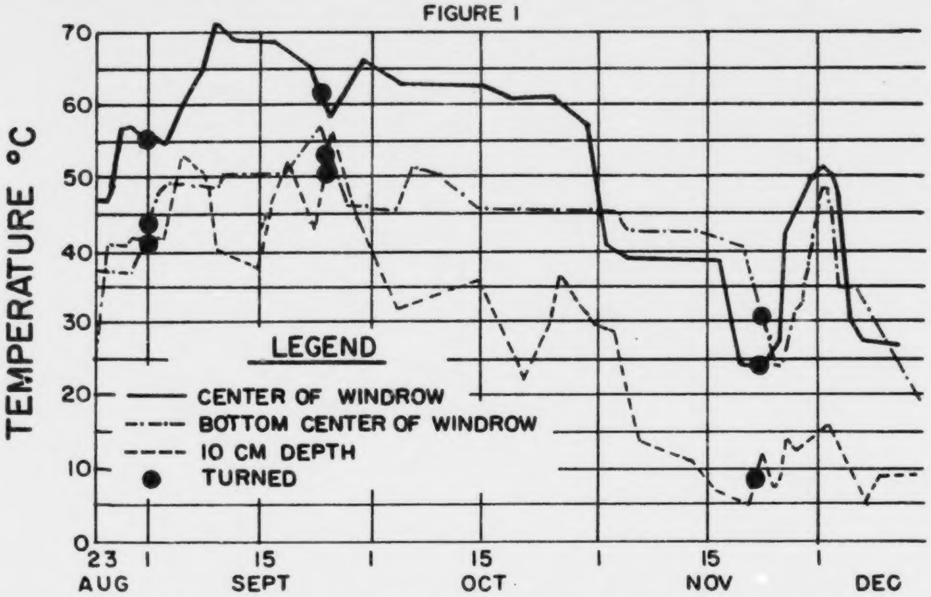
The piles were turned over 2 or 3 times and composted a total of 3-1/2 to 4 months. Evaluations were made of the following:

1. Pile temperatures
2. Pile moisture
3. pH value
4. Structure, color, odor of compost
5. Microclimate, relative humidity, precipitation
6. Physical values of compost (pore volume, density)
7. Plant-assimilable nutrients (by an ion-exchange procedure)
8. Organic and chemical analyses (active organic matter, C/N)
9. Bacteriological analysis.

Experimental results:

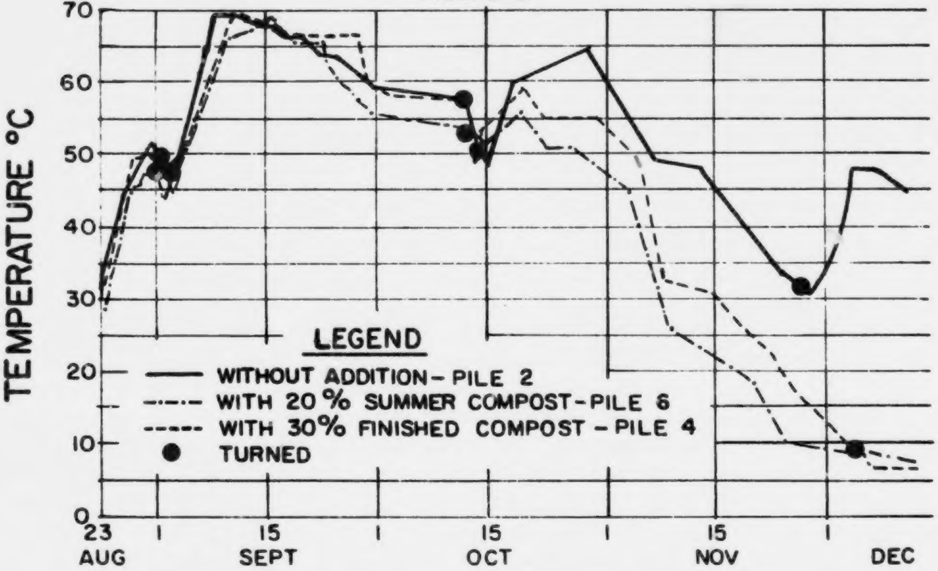
1. Pile temperatures - Initially, temperatures were measured daily, later 1 to 2 times weekly, using cased or metal thermometers of different lengths. Results showed the need for temperature measurement at different depths. The outermost layer, to about 20 cm. depth, reacted to a great extent to the ambient temperature, and to rains or dryness. Also in the first 40 cm., the decomposition proceeded more actively than in the deeper layers (see figure 1). Temperatures inside the

FIGURE 1



DECOMPOSITION TEMPERATURE IN CITY REFUSE-STABLE MANURE COMPOST

FIGURE 2



DECOMPOSITION TEMPERATURE OF CITY REFUSE COMPOST WITH & WITHOUT ADDITION AT 60 CM WINDROW DEPTH.

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pile averaged at least 20° C. lower than the maximum which occurred in the layer 30-40 cm. deep. After the first turning at about 10 days, temperatures rose 6-8° C. higher than before. With one exception, the temperatures did not exceed 70° C (158° F.). Average temperatures of 60° C. (140° F.) were maintained for almost 3 months. However, after 3-1/2 months, the temperatures usually declined.

2. Moisture content - Moisture was determined with a conductivity meter and a large number of plaster electrodes embedded in the windrow at various depths. Unfortunately, however, disadvantages were found in this method in time so that the procedure was not used in later experiments. Initial moisture content was about 50 percent and, while the outer layers soon showed a drying effect, the deeper portions had up to 18 percent more moisture than initially. The moisture content at the bottom-center was 5-8 percent higher than at mid-center. We observed that a lower initial moisture content should have been selected (45 percent at the highest), unless perhaps some means of aeration of the pile interior could be achieved.

3. pH value - The reaction was taken with a pH meter. Initially, the highest values were found in the outer layers (8.0 - 8.3), while the value decreased toward the core of the pile. During composting this tendency to decrease with depth shifted to a more general decline. The final pH values were 7.2 - 7.9.

4. Structure, color, and odor - Individual observations cannot be presented in this abstract but careful recording of such observations can assist in evaluation of a compost without claiming accuracy.

5. Determination of the microclimate, ambient temperatures and humidities, and precipitation were made at Heidelberg with the help of the German weather bureau.

6. Physical observations indicated that the pore volume in mature compost was 75 - 80 percent (culture soils 50 - 60 percent), and the density was 43 - 53 g./100 cu.cm.

7. A procedure developed by the Institut für Bodenkunde und Pflanzenernährung, Geisenheim, Rheingau, based on an ion-exchange method, was used to determine the plant-assimilable nutrient materials. This kinetic method of analysis gives particularly useful values but more experience is needed with refuse compost beyond the work done here. The values obtained in our experiments were well suited for establishing comparisons.

8. The Bavarian Landesanstalt für Pflanzenbau und Pflanzenschutz, Munich, also examined a number of samples. A discussion of results is not presented because of a desire for separate publication. It was generally learned that, while composting was completed in 3 months, only a little longer was required to result in a rise in stability.

9. Methods for bacteriological analysis were those of the Mikrobiologischen Instituts, Herborn, Dillkreis. The biological activity diminishes periodically, corresponding to the temperature, and reaches its maximum after about 8 to 14 days. It then declines, but there is an increase in physiological values towards the end of the process.

Conclusions:

1. The five piles with additives and the one without yielded good, marketable refuse compost. Analyses generally showed quite uniform values for the various admixtures.

2. Mixing half-ripe summer or winter refuse compost as inocula showed no benefit in accelerating decomposition (see figure 2). Also, the early drop in temperature towards the end of the observation period in all mixtures (excepting stable manure) justify this conclusion. Despite this, admixtures are suitable, if required in the operation, even though accompanied by poorer decomposition as undeniably evident in pile 5 with 20 percent winter compost.

3. A disadvantage of the additives was observed to be a packing of the mixtures due to the fine particles in the materials added.

4. Plant-assimilable food and active organic matter contents were at lower levels in the piles with admixtures than in the pile with refuse only; that is, the biological activity was lower.

5. Despite the large piles of the experiment (15 cu.m.), more favorable decomposition rates were observed in the experimental runs than in the normal windrow composting plant operations, where windrows are generally 3 m. high. This shows the importance of simulating operating conditions in research, as well as the importance of proper windrow height and aeration.

6. The addition of stable manure proved favorable. The organic, inorganic, and bacteriologic analyses showed definitely better quality.

7. Initial black (anaerobic) decomposition zones were eliminated by boring numerous 30 cm. wide air holes into the compost piles with a soil borer. It (aeration) was too low from the start in the pile without addition (pile 2).

8. A decomposition time of 3 months proved to be sufficient in these experiments, except for the admixture of stable manure.

9. Present knowledge is insufficient to permit satisfactory evaluation of the degree of maturity of the individual composts. Simple, practical tests for this would be particularly welcome. Also, evaluation measures for continuous observations should be developed so that the piles need not be disturbed.

These investigations show that planned observations and conscientious laboratory work give good results in refuse composting, even in a large-scale operation. We gratefully acknowledge the contributions of the various institutes to our project. It has also been shown that further development of analytical methods is needed to meet practical requirements. These first trials at Heidelberg represent only a modest beginning with all of the "childhood diseases" of such beginnings.

6. Simple Control Tests which Can Be Made by Compost Plant Operations. Communication from "Stichting Compost" (the Compost Foundation), Amsterdam.

1. Determination of hard particles (foreign matter) in refuse compost. It is very important to control the content of undesirable solid matter, such as glass, pottery, iron, and slag, in compost. Although it may be easier to analyze the ripe compost, it is more advisable to do it after refuse grinding but before decomposition. If these samples show excessive inorganic matter, one may usually eliminate the cause.

Recommended procedure: Take about a 1 kg. sample of freshly ground refuse ready for composting every hour. Mix these together thoroughly and take a daily sample of 3 kg. from the mixture. Sift the sample through a standard sieve with 6.8 mm. round holes. Hand sort the residue and determine the percent by weight of each classification.

The following maximum values are tolerated in high quality (gardening) compost in the Netherlands:

Maximum percent of particles larger than 6.8 mm.

Glass fragments	0.05%
Pieces of coal and slag	0.30%
Ceramics	0.10%
Iron	0.05%

For compost used in agriculture, a larger daily sample, 10 kg., is recommended. Sifting can then be done through 19 mm. and 13.6 mm. sieves. Permissible amounts of the hard materials depend on the purpose for which the compost is to be used and the claims established for it. Thus, for gravel- and stone-free soils from which potatoes are harvested by machine, there should be almost no solid particles larger than 19 mm. in the compost and the content of 13.6 - 19 mm. size should be no more than 0.5 percent.

In sorting samples for both agricultural and gardening uses, non-decomposable soft materials, such as rubber, nylon, and plastic, should also be regulated because these make the compost less attractive and accumulate in the soil.

2. Determination of moisture content. The most reliable method is the oven drying of a well-mixed sample (at least 10 g.) in an oven at a temperature of 105° C. If no drying oven is available, moisture can be determined with the help of a reflector (infra-red) lamp. The sample (more than 10 g.) is irradiated for a definite time, e.g. 15 min., with care taken that it is dried but not burned. Moisture is sufficiently accurately measured by this method. The sample should be taken from all parts of the cross-section of the pile because of local variations.

7. Discussion Corner

(Publisher assumes no responsibility.)

Mr. Georges Dobrouchkess, Paris, points out an error in reporting the price of refuse compost in Calais (see Info. Bull. No. 8, p. 15). The city sold the compost for 3.50 new Fr. fr./ton, exclusive of loading and hauling costs, at the beginning of 1960.

Ranger K. Blankenburg, Duisburg, sends us a description of the reforestation of city refuse dumps:

Dumps exist in all cities where refuse of all kinds are dumped. Boggy meadows or small ponds are often used for such dumping. When the fill reaches 1.5 to 1.75 m. in height, a bulldozer levels it and covers it with dirt taken from building sites. The possibility of reforesting the dumps is offered.

Decomposition of the organic component of the refuse results in heating the soil and raising the bacterial action, but severe damage to the trees may result (particularly in summer), if the soil is not loosened for the required aeration. Even insensitive grasses and weeds may not grow there, possibly because of injurious substances in the ashy residue. A mixed flora of weeds and such plants as tomatoes, hemp, daisies, grasses, and tree seedlings, such as apple, cherry, and red oak, may grow well under favorable conditions. The first year growth depends naturally on the type of soil covering the dump.

The following kinds of trees are recommended in order for reforestation of this type of refuse dump: poplar, silver poplar, white alder, Prunus serotina, willow species, birch, acacia, mountain ash, and both kinds of elders. These trees are unsuited for this purpose: oak, elm, linden, and red beech. White beech grows well at the dump edges.

A great drawback of reforestation can be the dense packing of subsoil of the dump by heavy traffic of garbage trucks. These roadways can be so hard-packed that even weeds cannot grow on them in spite of good topsoil cover. The sub-soil covering should be loosened with a subsoil raker before covering the dump area with topsoil to combat this condition. Reforestation of a refuse dump can only be successful when requirements are carefully met.

8. Information from the Secretariat.

a. Foundation of IRGR Group in Italy.

We are pleased to report that, upon proposal by the Institute of Sanitary Engineers of the Engineering School at Milan, the National Association of Sanitary Engineers decided to establish an IRGR group in Italy. The official Italian representation is the Institute of Sanitary Engineers at Milan under the direction of Dr. Eugenio deFraja Frangipane. The Information Bulletin is to be published in Italian and sent to interested persons.

b. New Rules Concerning the Information Bulletins.

At a meeting on June 22, 1960 in Zürich, the officers of IRGR decided to publish the Information Bulletin 3 times per year in the future. A charge will be assessed for those who receive the Information

Bulletin but do not belong to a national organization in order to cover the financing of the publication and the administration of the home office. The national group members, who send the Information Bulletin to interested persons in their countries, are likewise authorized to assess charges for this.

[Editor's note: Those receiving the English version of the Information Bulletin will continue to receive it *at no charge* so long as the CDC continues publication and no payment is required by the Zürich office. You will be notified in the event contributions are required.]

The Information Bulletin appears in four languages:

German: Secretariat of IRGR (Dr. R. Braun), Physikstrasse 5, Zürich 7/44, Switzerland.

French: (same as above.)

Italian: Instituto di Ingegneria Sanitaria del Politecnico di Milano (Dr. E. Fraja Frangipane), Piazza Leonardo da Vinci 32, Milan, Italy.

English: Department of Health, Education, and Welfare (Mr. John S. Wiley), P. O. Box 769, Savannah, Georgia.

c. Technical Papers Received by the Secretariat.

(*These papers may be obtained from: Sekretariat, IAM, Physikstrasse 5, Zürich 7/44, Switzerland, so long as they last.)

Baumann, E. (1960) : Pflanzenbauliche und betriebswirtschaftliche Fragen der Kompostierung von Wirtschaftsabfällen. *Der deutsche Gartenbau*. 7 (4).

Borchet, F. (1960) : Feste Abfallstoffe einer Grosstadt. *Der Städtetag*, 13 (5) 258-261.

Braun, R. (1960) : Die Technik der Müllaufbereitung. *Aufbereitungs-Technik*, 1 (4) 153-163.*

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Duhme, W. (1960) : Müllbeseitung als volkswirtschaftliche Chance. Der Städtetag, 13 (4) 204-206.

Jssleib (1960) : Die Technik der Kompostbereitung. Forsttechnische Informationen No. 4, Publ. Forsttechn. Informationen, Mainz.

Kampschulte, J. (1960) : Das Problem der Hausmüllbeseitung durch Müllverbrennung im In- und Ausland, insbesondere in Belgien. Städtehygiene, (4).

Kampschulte, J. (1960) : Städtereinigung. VDI-Zeitschrift, 102 (14) 589-595.

Kampschulte, J. (1960) : Zur Erweiterung der Müllverbrennung in Hamburg. Der Städtetag, 13 (2) 93-95.

Kaupert, W. (1958) : Müllverbrennung, Müllbrikettierung. Der Städtetag, (8).

Keller, P. (1960) : Die Beseitung von festen und flüssigen Siedlungsabfällen (Kehricht und Klärschlamm), Der Bund, Beilage Technik, No. 318, July 28, 1960.

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Rohde, G. (1960) : Nutzungsmöglichkeiten der Stadtabfälle zur Bodenverbesserung. Der deutsche Gartenbau, 7 (4) 92-94.

Rohde, G. (1960) : Was ist eigentlich Humus? Der Kleingärtner, 12 (11).

Schmidt, W.K. (1960) : Vorbereitende Arbeiten für die Planung einer Müllverbrennungsanlage. *Der Städtetag*, 13 (2) 91-93.

Tope, O. (1955) : Wirtschaftlichkeit der Strassenreinigung in Hannover. *Der Städtetag*, (9).

Tope, O. (1956) : Unhygienische Lagerung und Beseitigung von Müll in Krankenhäusern, Gaststättenbetrieben und Geschäften. *Desinfektion und Gesundheitswesen*, (12).

Tope, O. (1957) : Bakterien und Ungeziefer im Müll und auf Müllhalden. *Städtehygiene*, (10).

Tope, O. (1958) : Behandlung der Müllbeseitigung auf der Interbau Berlin 1957. *Städtehygiene* (10).

Tope, O. (1959) : Kriterium der Angaben über Menge und Gewicht von Müll. *Städtehygiene*, (6).

Wiley, J.S. (1960) : Composting of Organic Wastes, an annotated Bibliography, Supp. 2, *CDC*, 64 pp., Apr. 1960. (May be obtained from Savannah, Georgia.)

The following reprints are available from the Sekretariat, IAM, Physikstrasse 5, Zürich 7/44, Switzerland, at cost price, so long as they last.

Allenspach, H. (1956) : Untersuchungen über die gemeinsame Aufbereitung von Klärschlamm und Kehricht. (*Plan, Schweiz. Zeitschr. f. Landes-, Regional- und Ortsplanung*, No. 3).

Allenspach, H. (1958) : Die technischen Verfahren der Müll- und Klärschlammbeseitigung. (*Neue Zürcher Zeitung, Beilage Technik*, 18 (6) 1958).

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De Groote, R. (1957) : Analyse und Beurteilung der Qualität von Stadtmüll-Kompost. (Vortragstagung AkA Düsseldorf 1957).

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d. Working Session of der Arbeitsgemeinschaft für kommunale Abfallwirtschaft (AkA) [Work Group on Community Refuse Disposal].

September 30, 1960, City Hall smaller auditorium (opposite the Black Forest Hall), Karlsruhe, Germany.

MEETING PROGRAM

Friday, September 30, 1960.

9:00 a.m. Engr. B. Jäger, Technische Hochschule Stuttgart: "Processing Methods"

9:45 a.m. Dr. K. H. Knoll, Universität Giessen: "Hygienic Requirements and Procedures in Municipal Waste Disposal"

10:30 a.m. Dr. G. Farkasdi, Universität Giessen; Dr. Bardke, Technische Hochschule Stuttgart; Dr. Banse, Bad Kreuznach: "Composting Processes"

11:40 a.m. Dr. H. Apfelstedt, Deutscher Städtetag, Köln: "What do Cities Expect from the AkA?"

Noon Recess

2:00 p.m. "Round Table" Discussion

Concluding Discussions

Saturday, October 1, 1960

8:00 a.m. Bus trip to Compost Plants at Heidelberg and Baden-Baden.

(Ed. note: More details are given regarding applications, costs, and excursions which are not reproduced as the meeting has already occurred.)

INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)

Information Bulletin No. 10

December 1960

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1. Community Waste Disposal: Report of the AkA Meeting in Karlsruhe, September 30, 1960 by Dr. H. Straub, Director of Public Works, Baden-Baden.

A dozen years ago the problems of community waste disposal, thoroughly studied prior to World War 2 by the "Deutschen Gemeindetag" (the German Municipal League) were again considered. The disposal of solid community wastes, including sludge, refuse and industrial wastes, was recognized among the constantly growing problems of community development and sewage treatment and disposal. It is believed today that all waste disposal should be integrated, requiring the participation of multidisciplined experts. No time should be lost in the study of these problems which are urgent and could suddenly become overwhelming. The growth of industry and manufacturing was recognized and could be calculated but, along with improvement of living standards and a progressive economy, technical progress must be made in dealing with the wastes. Passage of the post-war years has unfortunately justified this thinking; the problems have become real and extend beyond national boundaries.

Today urgent problems exist in all communities as to what to do with the sewage sludge and what to do with the refuse. At the meeting of the Sewage Works Association at Munich in 1960, Müller-Neuhaus indicated that whether or not the sewage treatment plants urgently needed for water conservation could be built depended on suitable methods for treatment and disposal of the sludge. At the meeting of the Society of Municipal Street and Sanitation Officials at Karlsruhe in 1960 the Mayor of Frankfurt chose to speak on "The Disposal of Community Wastes--A Burning Problem". What was initially criticized as a prematurely posed problem, a few years later is discussed frequently at all such association meetings. It was truly none too early to delve into this complex subject.

The AkA (Work Group on Management of Community Wastes) was formed in 1952 and it is now supported by the Sewage Works Association, the Society of Municipal Street and Sanitation Officials, the German Municipal League, and the Municipal Association. The affiliation of other organizations is awaited, particularly the agricultural societies. Agriculture still stands aloof, concentrating on production and nutrition. Perhaps it should consider the increasing amounts of urban wastes constantly encroaching on new land, polluting the waters and fouling the soil, resulting in depletion of a substance which cannot be replenished at will. On the other hand organic fertilizers are not to be had because there is no production. Each group forms a part in the national economy and is therefore dependent upon economic prosperity. The community organizations forming AkA hope to provide practical solutions of the problems as rapidly as possible by comprehensive studies; while the communities will serve mainly for this, there should be true integration with the national economy.

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Some governmental agencies (the Ministries of Atomic Energy, of Water Resources, and of Nutrition, Agriculture and Forests) long ago recognized the importance of the waste problems. Appreciable appropriations have been made for basic research. Results have not been lacking. We now have a better concept of the nature, quantity and composition of community wastes and of their threat to the resources of soil, water and air.

In addition to refuse incineration, which has had 70 years of successful development, the processes of composting refuse and sludge and, more recently, sludge incineration have appeared. It is important in composting that biological degradation be apparent during the decomposition process. It is often wished that compost equipment manufacturers would incorporate the findings of research workers to assist in solving equipment problems. Countless trials and investigations by agricultural experts have shown that the composting process results in products possessing valuable soil-improving properties which ought not to be neglected in view of the present lack of humus and physical soil fertility. Trace elements, formerly not highly regarded, as well as the humus and enzyme content of the compost, have recently acquired a new importance according to authorities in biology, humus, farming and gardening.

Discussions for several years in AkA meetings and scientific publications from research institutions have formulated authoritative concepts worthy of support. The AkA presented the status of research in this field at the meeting in Karlsruhe and published the information in a manual "Collection, Processing and Utilization of Community Wastes" (copies may be requested from the home office in Baden-Baden). This is the first concise, standard work published in this new field of science. Some concepts were explained to a greater extent by the papers presented at the meeting; nevertheless, the speakers were only able to give a (brief) insight into this new field of science. Specific questions of the participants were aired in a round table discussion lasting several hours. This discussion was an experiment which led to interesting conclusions. The main participant interest was on basic data concerning the composition and quality of urban refuse and its various properties as well as conclusions regarding composting and incineration.

The papers are published in various journals but additional findings must be constantly supplied in future publications. The AkA will collect informative material and publish it in comprehensive reports.

Engineer Jäger, Technische Hochschule, Stuttgart, reviewed the present status of refuse treatment processes. He also brought out certain disadvantages of some processes and the scientific findings applicable to the technique of refuse treatment. A film of the composting plant at Calais was shown by the Société Générale d'Epuration et d'assainissement, Paris. The solutions proposed at the Calais plant are very interesting. The positive evaluation of the incineration process by Jäger is appreciated; he stated that local conditions should determine whether an incinerator or a composting plant is selected. All plans should therefore be the result of careful investigations of local conditions, including a weighing of advantages and disadvantages of contemplated processes. This paper is presented in the journal "GWF" (Gas-und Wasserfach).

Dr. Knoll, Justus-Liebig-Universität, Giessen, described the basic health aspects that must be met for all processes, incineration as well as composting. Complete freedom from pollution of water and air is a strict hygienic requirement of the processing technique. Incineration will meet hygienic requirements if there is sufficient filtering of the waste gases and dust and fly ash contamination is prevented. Knoll described his own studies which repeatedly showed pasteurization of urban wastes by the composting process. Even resistant pathogenic microorganisms can be definitely eliminated if certain optimum conditions of decomposition are maintained. These include a moisture content of 40-60%, at least two weeks of decomposition at temperatures up to 60°C, and at least one turning or mixing. (Ed. note: This is in the windrow or rasping system composting process.) Knoll showed that pathogens are not destroyed solely by thermal kill but also by an antibiotic action produced by the organisms causing decomposition, and the overwhelming growth of decomposing organisms causes a transformation of the microorganism population. These results have aroused interest because, from a public health viewpoint, they seem to eliminate the need for the high temperatures formerly required for pathogen destruction. This paper will appear later in the journal Städtehygiene.

Three other papers, which also will probably appear in Städtehygiene, reviewed the research work of the Giessen group at the Justus-Liebig University. Dr. Farkasdi, collaborating with Dr. Straub, reported systematic studies on the composting process at Baden-Baden in which optimum conditions for aerobic decomposition were ascertained. Microbiological analysis enabled examination of the influence of temperature and moisture content on biological decomposition. Certain influences on the decomposition and its progress can be gained by providing favorable environmental conditions for microorganisms. The effects of the composition of raw material have also been demonstrated.

Dr. Bardtke, Technische Hochschule, Stuttgart, demonstrated the fluorescent microscopic technique on the microflora of refuse compost and sewage, giving an insight into the nature of microorganisms responsible for decomposition. In conjunction, metabolism was measured by means of oxygen consumption and CO_2 production to elaborate on the decomposition process. These values corresponded well with those reported by Farkasdi in the practical trials at Baden-Baden.

Dr. Banse, Soil Improvement Society, Bad Kreuznach (Dano plant) reported outstanding success in erosion prevention in vineyards (through compost application). The observations were confirmed by careful measurements in vineyards at Weinsberg and Eglisan (Switzerland) where compost was more effective in preventing erosion than stable manure or mineral fertilizers. Thus, aside from other soil improvement activity, we can show specific benefits for its use in vineyards.

Most papers dealt with composting which should not indicate a decrease in the importance of incineration. Composting is a more recent development and poses many more unsolved problems demanding study. Sessions were devoted to the technical and biological problems, the interesting topic concerning the effects of compost on soil improvement being limited to the paper by Banse. Agricultural problems will be reserved for another meeting. This meeting was conducted jointly with that of the Society of Municipal Street and Sanitation Officials and we wished to address ourselves to these municipal representatives.

In conclusion, Dr. Apfelstedt, representing the German Municipal League and president of the Water Commission, spoke on "What do Cities Expect from the AkA?". He reviewed the history of AkA and suggested its future course. Many questions raised by Dr. Apfelstedt are already answered or under study. However, many others pose a new series of problems, indicating an increase rather than a decrease. Apfelstedt correctly stated that AkA, being strictly a voluntary organization, will find that it cannot solve all the problems due to limited means. It is time to consider establishing projects in research institutions. We already rely on the conduct of projects by institutes with AkA directing and coordinating the research. The paper pointed to the reality of the many problems concerning urban wastes and showed that the proper approach is being followed.

On the following day the participants visited the compost plants at Baden-Baden and Heidelberg and the BASF incinerator at Ludwigshafen.

2. The Significance and Methods of Evaluation of the Maturity of Refuse and Refuse-Sludge Composts by Dr. P. Keller, Swiss Water Pollution Control Federation, Zürich.

Introduction

In such thickly settled regions of Europe as Switzerland, there is very limited dumping area for refuse and only the largest cities can finance incineration. Additionally, sewage treatment plants are having difficulty in selling sludge, and composting sludge jointly with refuse appears to be the only solution if the sludge cannot be dispensed directly to the farmer. Composting of refuse and sludge per se might be very desirable because the compost quality is considerably improved; but special composting requirements must be met because of the high moisture content of sludge (danger of putrefaction). Very strict hygienic requirements must be established for the process, if composting is carried out with fresh sludge instead of digested sludge, as is the general aim today.

Joint refuse-sludge composting may significantly increase in the future. Humus requirements for the soil are well met in certain regions such as Switzerland where agricultural requirements are small due to extensive cattle farming (large manure yields and extensive crop rotation). This provides a compost disposal problem. Potential consumers are chiefly market gardeners (including home gardeners), winegrowers and nurserymen. In all these fields considerably greater compost application rates are used than in agriculture and a higher quality compost is required, including strict limitations in content of plastic, glass and ceramic particles. Large applications of compost permit greater danger of failures in cases of improper use; these failures may severely impede successful sale of the compost.

It is therefore concluded that, in regions where no urgent need for compost exists and where composting of refuse and sludge is the most satisfactory disposal method, the following conditions must be fulfilled:

- The compost must meet all hygienic requirements.
- The proportion of undecomposable materials in the compost should be as low as possible (glass, rubber and plastic fragments).
- The possibility of (application) failures, even in the event of use of large amounts of compost shortly before or during the growing period, must be reduced to a minimum.

Many scientific and practical experiments in Switzerland and elsewhere show that only properly composted, adequately cured, well-screened and refined compost fulfills all these requirements. The technique of refuse processing today is at a high level and it is possible to prepare the raw materials for optimum composting without further study (Braun 1960). There are widely divergent and contradictory views, however, concerning the period of composting necessary to attain the proper degree of stability and to determine the degree of maturity. An attempt will be made to define the degree of maturity, to describe procedures for its determination, and to discuss the advantages and disadvantages of the use of mature versus fresh compost.

Definition and Significance of Degree of Maturity

Microorganisms active in aerobic decomposition (bacteria, actinomycetes, fungi) require large amounts of carbon for their growth and metabolism (source of energy). The organisms are heterotrophic, that is, they cannot assimilate CO_2 directly from the air with the aid of sunlight; so they depend on the presence of organic carbon compounds as sources of food and energy. Easily assimilable carbon sources, such as carbohydrates, are 80 to 95% mineralized during the decomposition process; that is, they are decomposed to CO_2 and H_2O with release of considerable energy in the form of heat. This energy is also used to construct cells which, after death, are in turn utilized by other microorganisms which follow. Carbon difficult to assimilate, such as lignin and humic materials, are generally decomposed only in the presence of more readily assimilable carbon with mineralization occurring only partially and at a very slow rate. Organic compounds yielded by the microorganisms or incorporated into their cells are also frequently difficult to decompose.

If other conditions favor decomposition (nutrients, pH, O_2, etc.), the presence of much assimilable carbon (large supply of energy) sets up an intensive decomposition (high microorganism count, temperature, and CO_2 production) during which difficultly assimilated carbon is also attacked. When the supply of available carbon is exhausted and that of the bound carbon is increased, the energy supply, and therefore the decomposition intensity, become very small (lowered microorganism count, temperature, and CO_2 production). Then a degree of stabilization has been reached in which we designate the compost as being ripe or mature. The mineralization continues at a much slower rate, gradually transforming even relatively stable compounds into lignite-like products with high carbon content, called humins or humic carbons. Such a compost is considered as overripe and possesses only limited value as a soil-improver.

Thus, the first stage of composting provides preliminary decomposition in cells or according to the process used to a relatively stable end product. Products of this treatment include raw prepared refuse or refuse-sludge (sorted, ground, mixed) or partially decomposed compost. Both may be used directly for many purposes. The question is that of determining the advantages of ripe compost over these two materials.

An essential requirement of compost derived from urban wastes is that of hygiene; it must be free from pathogenic organisms and worm eggs, also from weed seeds. These conditions are met by compost which has undergone appreciable thermophilic decomposition with temperatures over 45°C (Gotaas 1956). It is evident that raw refuse-sludge cannot be directly dispensed to the consumer without some trepidation. Thus, treatment procedures providing predecomposition are clearly preferable, but it might be asked whether short-time decomposition is sufficient to destroy such highly resistant forms of organisms as spores, cysts and seeds.

The following effects should be attained through the use of compost:

a. Improvement in soil structure with greater friability and pore volume resulting in improved moisture distribution and exchange of gases.

b. Increased moisture retention capacity combined with reduction in soil drying due to drouth caused by the water-retaining property of humic substances.

c. Increased retention of plant nutrients and trace elements in the soil, due to the ion-exchange properties of humus (slower and more uniform release of nutrients to the crop, reduced leaching).

d. Prevention of erosion by the action of humus in creating a more crumbly soil texture.

(These effects of humus increase proportionately to its content in the soil up to a certain point. The essential aim of compost application is therefore in raising, or at least maintaining, the humus level in the soil.)

e. Promotion of plant growth by:

   1. Providing slowly available nutrients and trace elements (fertilizing action of compost, particularly of refuse-sludge compost).

2. Enhancement of the micro- and macrofauna of the soil (formation of certain organic compounds which can be assimilated by higher plants and stimulate growth; prevention of development of soil parasites, often appearing in soil devoted to a single crop; fixation of mineral nutrient elements into plant-assimilable forms).

Comparison of the action of mature compost with raw or pre-rotted refuse reveals: Points a-d: Fresh organic matter is swiftly decomposed in the soil, creating humus. Yet, during this period, available humus sources in the soil are used up by microorganisms in their need to obtain available carbon. Therefore, in the long run the soil humus content is raised only a little or none at all through use of fresh or slightly decomposed material. This was demonstrated over a period of more than 100 years in England and Germany by experiments with stable manure. Mature compost, on the other hand, considerably increases humus content which increase is, of course, less in soils already having a high humus content (a point of equilibrium is reached where humus addition and decomposition become balanced). Point e: Addition of fresh organic matter to soil causes marked microorganism activity which may have as a sequel the fixing of nutrients, particularly N and P, and an oxygen depletion. These effects may be desirable, for example, if a leaching out of nutrients is to be prevented during the winter fallow. But most crops respond to a large application of fresh organic matter by a decrease in yield (when applied) during the growing season. Particularly endangered are sprouting seeds and young growths. Besides fixation of nutrients, certain products of decomposition (enzymes) seem to be formed which also attack rootlets and may cause reduction in yield.

Only mature compost should therefore be applied shortly before or during the growing season. The humic materials in mature compost more favorably influence plant growth than the same in raw or overripe materials (Schobinger 1958). Generally, the Dutch experiments showed that better results are obtained on heavy clay soils with immature composts than with mature composts, whereas the reverse is true on light sandy soils.

It follows, then, that the use of mature compost leads to better results in most cases. Raw refuse may be more favorable under some circumstances but special knowledge is required by the user to avoid failures. Where intensive horticulture and gardening, not agriculture, prevails and refuse-sludge compost is to be used in large amounts, only ripe compost should be distributed by composting plants (except for special cases such as in hotbeds). This guarantees fulfillment of hygienic requirements and reduces failures due to improper use to the lowest possible level. The ultimate purpose of compost--the increase of humus content in the soil--is thus best achieved.

Determination of Degree of Maturity

a. By observation (odor, structure, color, specific gravity):

During decomposition an organic material changes greatly in appearance; the color and structure of the initial material generally disappears completely. Mature compost is dark brown to brown-black, regardless of the original material. Initial constituents, such as scraps of paper, remnants and vegetable peelings, are no longer recognizable. Fresh organic material initially undergoes an acid decomposition phase and has a typical acid odor. Foul odors may appear in the center of a compost pile under anaerobic conditions, with production of H_2S, NH_3 and amines. These are indications of putrefaction. These odors disappear in time, even in anaerobic decomposition, and the mature material smells like forest soil (typical soil odor is caused by actinomycetes). Specific gravity increases during decomposition, from 0.2-0.5 to 0.5-0.9 in the case of refuse composts, according to the composition of the initial material.

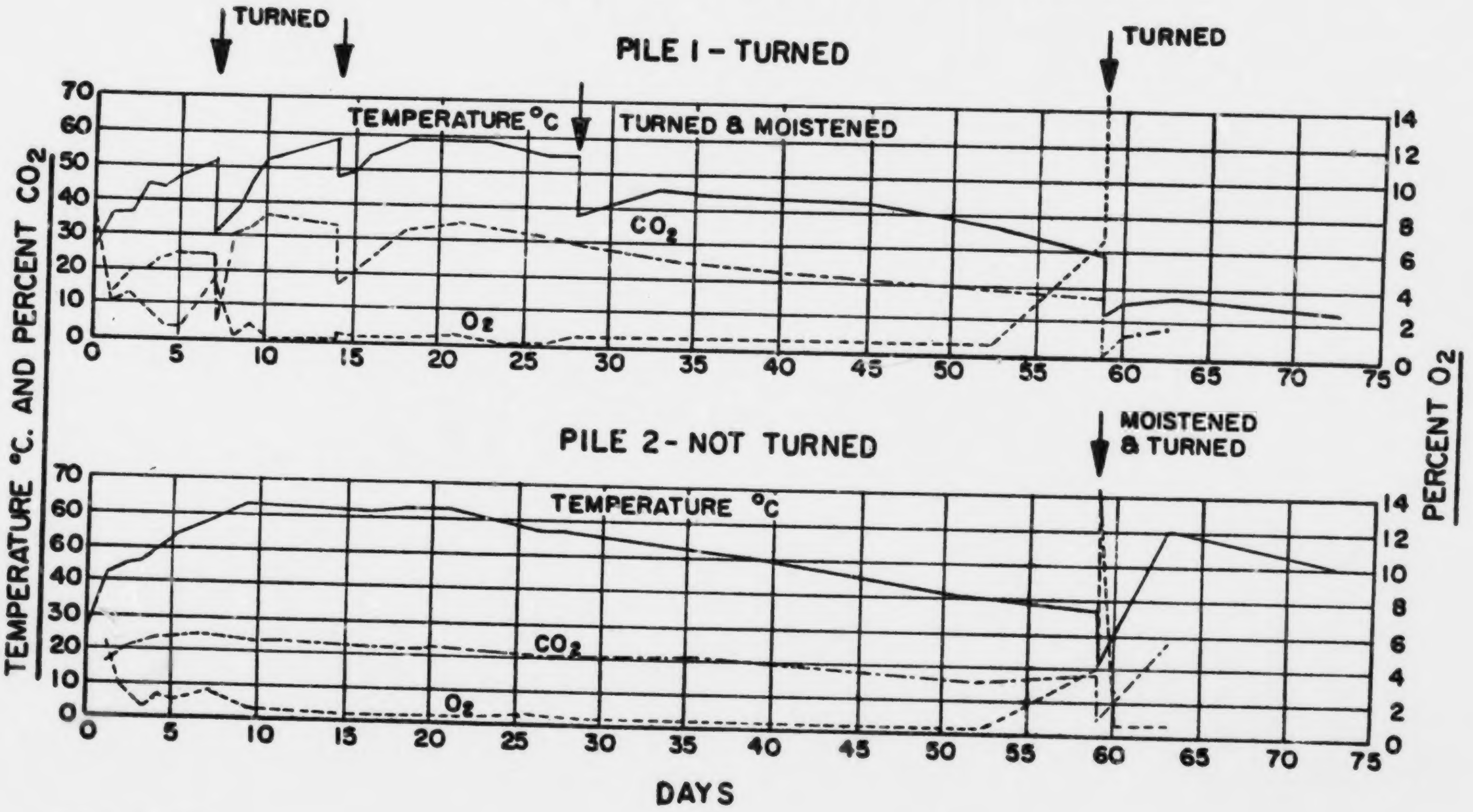
Determining degree of maturity with the aid of these observations may furnish some information if the observer is sufficiently experienced. There is great danger of erroneous interpretation, however, in the case of refuse and refuse-sludge mixtures; refuse compost, which has been mechanically ground and undergone only a brief period of decomposition in fermentation chambers, often looks bewilderingly like a mature compost although it is still far from ripe.

b. By the course of decomposition:

Fresh organic matter passes through characteristic stages when decomposed aerobically, providing favorable conditions exist (nutrients, moisture content, pH, oxygen supply). Temperatures rise rapidly to the thermophilic region (over 45°C). The pH values generally are in the acid range during the first stage if the material is not highly buffered, as generally the case with refuse and refuse-sludge. The compost remains for some time in the thermophilic temperature range (second stage), the duration depending on size of pile, frequency of turning and moisture content (windrow composting). The CO_2 content is high and the O_2 content is low (0 to 1%) as a result of the intense decomposition during the thermophilic phase (see Figure 1). In the third stage the temperature drops again to the mesophilic

FIGURE 1

TEMPERATURE, CO_2- AND -O_2 -CONTENTS WITH TIME OF DECOMPOSITION, MEASURED AT 35 CM DEPTH (CENTER).



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range, the CO_2 content decreases, and the O_2 content increases. When the temperature of the pile has dropped to that of the external surroundings and does not appreciably increase on further turning of the pile, the fourth stage has been reached--that of true ripeness. The gas composition within the pile approaches that of external air as a result of the marked reduction in decomposition rate.

Figure 1 shows an experiment conducted with refuse pre-composted in a rotating drum for about 3 days. Two experimental piles 1.5 m. high were formed, one of which was periodically turned and wetted, the other being left untreated for 60 days. At intervals the temperature, O_2 and CO_2 contents in the piles were measured. Samples were taken for chemical analysis and planting experiments every 14 days.

The influence of proper composting is clearly shown in the intensity and duration of decomposition; that is, periodic turning and, if necessary, moistening of the pile. Pile 1 maturity was attained in about 60 days, that of pile 2 only after 80 to 90 days. The influence of processing is shown more clearly in the comparative cellulose contents shown in Table 1. (In experiments with a synthetic garbage in an aerated chamber (Schulze 1957), as well as in our experiments with ground refuse in perforated plastic containers, maturity was reached in only 2 to 3 weeks!)

Planting experiments verified that the material in the turned piles was actually mature after 60 days. Initial yield decreases, due to fixing of nutrients, declined with increasing age of compost and, indeed, considerable yield increase occurred in plants treated with the compost matured about 50 days.

The simplest practical method of determining degree of maturity is probably the follow-up of the course of decomposition in the compost piles. It follows from Figure 1 that the CO_2 curve runs more or less parallel to the temperature curve, shown repeatedly to be the case in similar composting experiments. It is therefore entirely adequate to measure the temperature every two days. This is best done with a long-stemmed bimetallic thermometer or with thermisters. It is necessary that the material be turned over several times and moistened, if necessary. Turning is desirable for other reasons--shortening of compost time and therefore space-saving, certainty in hygienic aspects by insuring that outer layers of the pile undergo the thermophilic phase, better appearance of the compost as a result of mixing and homogenizing.

Table 1

Cellulose and Lipids Contents of Piles 1 and 2 During Decomposition

Materials	Lipids** (Soluble in alcohol-benzol, 1:1) %	Cellulose		
		mg/g	in % of volatile solids (ash-free)	in % of active organic matter
Pile 1:				
Raw material	7.7	258	34	44
14-day	7.4	218	30	37
28-day	5.3	152	22	29
42-day	3.9	83	13	17
60-day	3.8	76	12	17
75-day	3.2	65	10	14
115-day	2.2	58	9	12
Pile 2:				
Raw material	7.7	258	34	44
14-day	7.8	204	28	40
28-day	6.0	217	31	41
60-day	6.5	147	21	30
75-day	4.4	86	13	17
115-day	2.3	70	11	15
Normal compost pile at Ruschlikon, 45-60 days old*	6.6	216	30	40

* Same initial material as piles 1 and 2 but predominantly anaerobically piled (very large compost piles, not turned).

**The extraction of compost with alcohol/benzene or ether is necessary for the determination of cellulose because the lipids reduce the solubility of cellulose in its extracting agent.

c. By chemical analyses:

The usual complete chemical analyses (moisture, organic matter, nutrient materials, pH, etc.) possibly provide information on the quality of the initial materials or of the compost, but gives little information on the degree of maturity. Special chemical analyses have been developed to enable this determination. The more important methods are presented.

1. Carbon-nitrogen ratio (C/N).

The C/N is most frequently and widely used for determining degree of completion of compost. Organic carbon is oxidized to CO_2 by dry or wet combustion and measured as CO_2. N is usually determined by the Kjeldahl method. The C/N also serves as an index of the decomposability of the material. A C/N of over 50 indicates that nitrogen must be added to obtain proper decomposition. A C/N between 30 and 50 permits relatively fast decomposition with no significant N loss. A C/N of under 30 can result in loss of N, particularly by anaerobic decomposition. Matured compost or different forms of soil humus have C/N values between 10 and 20.

The C/N value is only an indication of degree of ripeness or of decomposability when the C and N contents exist in available form in which they can be assimilated by microorganisms. This is generally true for purely vegetable wastes such as wood, forest and garden wastes. The situation is quite different with refuse-sludge composts. Thus, Dutch reports show that up to 50% of the carbon content in winter refuse can be attributed to remains of fuels (coals, coke, etc.) and are thus biologically inert materials. Constantly greater amounts of synthetic materials are found in refuse (plastics, rubber, etc.) and are similarly inert. The same is true of the nitrogen in refuse, as the amine-based plastics used today in large quantities are only difficultly assimilated. Part of the nitrogen, after only a short decomposition time, may become fixed in organic compounds that are non-available, such as heterocyclicly fixed nitrogen in humus substances.

Determination of available or biologically active C and N has been attempted to solve this problem. Available C is readily determined by first determining the total C then determining the carbon content after the material is treated chemically (alkali extraction, hydrolysis) (Springer 1957). The difference is the amount of active carbon. Determination of active nitrogen is considerably more difficult.

A determination method for active C/active N in mature compost cannot be applied to raw refuse or fresh organic material. Another difficulty is that the nitrogen in leather and hair, while not biologically inactive, is decomposed only with difficulty. Particle size and distribution of such materials are important because, while chunks of leather are practically nondecomposable, finely ground leather is considered a good source of N for composting. But structural differences are not revealed in chemical analysis.

Different methods of determining C/N result in differing values, in some cases being far apart. Therefore, C/N appears to have limited use as an index of degree of maturity.

2. Nitrite/nitrate nitrogen:

Part of the nitrogen in organic compounds is released on breakdown as NH_3. Depending on circumstances, the greater part of NH_3 is either assimilated by organisms or oxidized by N-fixing organisms to NO_2 or NO_3, or it escapes to the outside air (loss of N). Refuse and refuse-sludge composts normally contain minimal quantities of N so escape of NH_3 is not likely to occur and the NH_3 is immediately taken up by the organisms. But in the latter stages of decomposition, part of the ammonia may be oxidized to nitrites and nitrates. Existence of nitrite or nitrate nitrogen is an indication that the compost is ripe.

Decomposition studies with refuse-sludge compost show good correlation between nitrite/nitrate determination and other methods of determination of degree of maturity (Braun and Allenspach 1958). But in some samples of unripe compost, large amounts of NO_2/NO_3-N have been found. This method gives only an indication, not a specific determination, of compost completion and consequently can only be used in conjunction with other methods.

3. Cellulose content:

Cellulose is the most widely distributed organic substance in nature. Its proportion to the (total) decomposable substances is relatively high (30 to 60% in Switzerland) and additionally shows a tendency to rise as use of paper increases and home burning and salvaging of paper decreases. About 80 to 90% of the cellulose originally present is broken down by composting. Determinations of the cellulose content and its percentage of the total and assimilable organic matter at various degrees of composting give a good index for intensity of decomposition and degree of maturity of compost (see Table 1).

For determination of cellulose in heterogeneous materials, such as refuse or refuse-sludge composts, extraction with Schweizer reagent (copper ammonium complex. Methods: Heuser 1946, Dorée 1947) has proved good. Extracted cellulose is precipitated with acid and gravimetrically determined. Viscosity meter determinations are unsuitable, as compost cellulose has been largely decomposed.

4. Humus analysis:

Relatively stable humic compounds are formed upon decomposition of organic materials and these give lasting improvement to the soil or compost. Humus substances, in the presence of nutrient and available carbon sources, will in time be decomposed to lignin-like inert organics or are mineralized.

Humus consists mostly of aromatic nuclei which, by means of linkage formation, may combine to high molecular compounds (humic acids) and which show acid-reactive characteristics (carboxyl and phenolic hydroxyl groups). Elucidation of the structural constitution of these compounds is now very difficult but, in Germany and the lands of the East, the problem is being intensively studied (Kononowa 1958, Scheffer and Ulrich 1960).

Many trials have been made to determine the degree of decomposition or stage of humus formation of organic substances in soil by chemical analysis (Thun and Herrmann 1955). These methods are based on the different solubility of true humus substances in contrast to those in fresh or decomposing organic matter, in various solvents such as acetylbromide; on the determination of the relative proportions of different substances in the whole of the organic matter (substance group analysis); on the colorimetric determination of alkali-soluble humus components by color comparison with standard preparations. Each analysis yields characteristic results which, when taken together, should give a complete picture of the type of humus and the humus content of a given soil. Possible errors in determining humus coefficients are so great that their usefulness in characterizing soil humus is often doubted (Scheffer and Ulrich 1960). We know of no attempts being made to determine humus coefficients for refuse or refuse-sludge composts, and the possibility of error may be still greater than that for soils.

There are three main groups of humus substances on the basis of acid and alkali solubility:

- Fulvic acids (low molecular, soluble in alkali and acid)
- Humic acids (high molecular, soluble in alkali, precipitated in acids)
- Humins or humus carbons (high molecular, insoluble in alkali and acid)

The most important are the humic acids. They are readily determined gravimetrically because of their solubility in dilute alkalis and precipitability in dilute acids. An important property of humic acids is their great cation exchange capacity (200-500 milliequivalents/100 g. for soil humic acids), constituting 30 to 60% of the total soil cation exchange capacity (Baver 1930, Scheffer and Ulrich 1960) and contributing greatly to prevention of mineral nutrient loss due to leaching. The cation exchange capacity of humic acids may be simply determined by titration. We have attempted to find the degree of maturity of composts by determining the cation exchange capacities of the humic acids in them. The humic acids content, astonishingly, remained about the same throughout the decomposition period. This may be due to extraction of other substances, such as polysaccharides and lignins, in the early stages. Thus, humic acid content cannot be used to measure degree of completion of a compost. Quality of mature compost can, however, be assessed by this method, as refuse-sludge compost has about double the humic acids in refuse compost. Use of sludge with refuse in composts considerably improves the quality.

It follows that humus chemistry has not progressed far enough to produce simple tests measuring the degree of compost maturity. Future studies may develop such a test.

5. Biological studies:

Kononova (1958) indicates that humification of vegetable debris occurs with the following microbial development:

Molds, non-spore-forming bacteria → Sporogenic bacteria → Cellulose-decomposing myxobacteria → Actinomycetes

(In all stages of decomposition all of these organisms are present in one form or another; this synopsis merely indicates the dominating organisms.)

Actinomycetes, appearing in the final stages, possess the capacity to form certain humic substances, as well as to utilize existing humic sources of C and N. The typical earthy odor of mature compost and forest soil is due to actinomycetes. Following the microbiology of composts, on the basis of typical organisms, might permit determination of degree of ripeness. Projects in this direction, however, have not proceeded very far.

Gardeners consider the appearance of the higher forms, such as earthworms, to indicate ripe compost. Large numbers of earthworms may be present in both immature and mature composts as long as the temperature of the area is less than 30°C and adequate moisture is present. This criterion is consequently quite uncertain.

Decomposition subsides, after the intense initial phases, and reaches a state of stability after some time (Figure 1). Stabilization is traceable to lack of available C, assuming other nutrients and water are adequate. Biological activity may then be a criterion of stabilization. This would involve: microorganism counts, measurement of enzyme activity, and measurement of O_2-consumption or CO_2-production. Little is known concerning counts of organisms. Bucksteeg and Thiele (1959) developed a reductase test for liquid wastes and sludges based on a change in colorless 2,3,5-triphenyl-tetrazolium-chloride by reducing enzymes into red formazan, the red dye being extracted with alcohol and determined colorimetrically. Reductase activity in sludges parallels the biological activity (as measured by O_2-consumed from permanganate) and the numbers of organisms.

We tried to apply this technique to refuse compost in small experimental piles. Color increased initially, decreased and reached a minimum at about the time other factors indicated maturity. Later, however, coloration increased, in some cases to values higher than in initial stages. There were difficulties also in proper sampling. Results therefore appear questionable for refuse composts.

Wiley (1955) and Schulze (1957) measured O_2-consumption and CO_2-production to evaluate intensity of decomposition. These experiments were made in aerated chambers and calculations based on the analysis of gases discharged. More accurate values can be obtained with the Warburg apparatus, but questions arise as to whether the 1-2 g. samples are truly representative of conditions in the compost heap. Wiley and Schulze showed correlation of O_2-consumption and CO_2-production curves with temperature. The O_2-consumption is 5 to 10 times greater in the intensive, as compared to the mature, stage.

Unripe compost can cause yield decreases or damage to crops due to fixation of nutrients or to formation of toxic products. Studies were made with Versuchsanstalt für Obst-, Wein-und Gartenbau, Wädenswil, to determine compost maturity by simple planting trials. Plants of moderate sensitivity, such as wheat and beans, were grown in soil-compost, soil, and compost with yield measurements. Table 2 shows the results with compost of different ages.

Table 2

Influence of Refuse Compost on Yield of Summer Wheat
(Same materials as in Figure 1 and Table 1)

% Increase or decrease in above-ground plant weight, based on control with field soil = 100%.

Compost/Soil Mixture	Age of Compost				
	Raw	14-day	30-day	45-day	60-day (ripe)
Compost	-49	-53	-32	-7	+49
1:1	-38	-43	-9	+23	+50
1:5	-35	-42	-9	+10	+35
1:10	---	-37	-9	+1	+22

The plant-growth research, combined with chemical analyses, was very suitable in evaluating the stages of decomposition. Alone, however, the plant studies can lead to erroneous conclusions. Many variables, including light and temperature, strongly influence the results and such experiments are best conducted in greenhouses under controlled conditions. Yield depressions with green compost may be caused by inadequate nutrients for both plants and microorganisms; therefore a soil of low nutrient composition should be selected for comparative tests.

Summary

Small- and medium-sized communities may find composting to be the only satisfactory solution to their waste problem. Compost must be properly prepared, correctly composted, and matured.

Compost is considered to be mature when available C has been largely consumed and decomposition proceeds only very slowly. Use of mature compost gives generally better results than immature compost or raw wastes. The ultimate aim of compost application, increase in soil humus content, can only be attained using mature composts.

Degree of maturity can be determined by the following methods:

a. Based on physical characteristics (odor, color, structure, specific gravity). Erroneous conclusions are possible.

b. Based on temperature. Compost is considered mature if, after turning and moistening, it no longer spontaneously heats up. This method is simple, practical for compost plants, and reliable.

c. Based on chemical analyses. The C/N is limited in the case of urban waste composts but is applicable to homogeneous materials. The NO_2- and NO_3-N tests are very unreliable. Cellulose content is a good index and best suited of the chemical tests. Humus chemistry is not sufficiently progressed for reliability.

d. Based on biological studies. Presence of earthworms may be misleading. Microorganism counts, CO_2-production and O_2-consumption may give comprehensive indications, the latter two being of greatest importance. Plant growth tests are subject to appreciable errors and should be used only in conjunction with other techniques.

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3. Use of Refuse Compost in the Netherlands, 1959 by Engineer B. Teensma, Amsterdam.

The 12 municipal compost plants in the Netherlands (Wijster, Mierlo, Delft, Schiedam, Enschede, Almelo, Hengelo, Venlo, Sneek, Vlissingen, Soest-Baarn, and Dantumadeel) disposed of 194,331 metric tons of refuse compost in 1959. About 164,000 tons (84.5%) were marketed by the V.A.M.

The following shows the use of compost for the year 1959 (in metric tons):

	Tons	%
Grassland pasture	7,678	4.0
Field cropland	63,664	35.3
Mixed with stable manure	17,752	9.1
Chicken litter	3,777	1.9
Forest culture	6,066	3.1

	Tons	%
Parks, gardens, playgrounds	43,321	22.3
Horticulture	4,988	2.6
Market gardening	25,055	12.9
Hotbeds (also for market gardening)	9,714	5.0
Flower bulb raising	7,316	3.8

Largest consumption continued to be in field crops, but the proportion is gradually reducing in favor of market gardening, and park use, particularly in recent years. Improving land tilth is in this category but only 20% of the compost on croplands was used for making land tillable (reclamation?). Twenty years ago forestry and land reclamation accounted for nearly all the compost used.

Newer compost plants produce finer and better quality compost which, however, is too costly for field crops. This accounts for the decrease in field crop use. It is clear that demand for high quality compost is great. This encourages modern compost works to produce fine compost because of its higher selling price. Compost use in parks, playgrounds and community and private gardens is in second place. Only refined composts can be used here and the demand is increasing.

Market gardening use is third with 17.9% of total consumption (12.9 as compost, 5.0 as hotbed manure). This is due to greater scarcity and cost of stable manure. Straw is required in preparation of stable manure, but it is attaining increased use in industry and is becoming too costly for manure preparation. More and more farmers decide to stop preparing stable manure, saving only feces and urine to apply to their own land.

Flower bulb culture is using more and more compost even though conducted only in western Holland. Western compost plants cannot supply the demands of market gardeners and bulb raisers, requiring shipment by canal or by land from eastern plants.

Many farmers mix compost and stable manure (9.1% of total consumption) but this is only in northern Holland. Most of such mixtures are used on field cropland, a lesser amount on pasture land. The forestry project in the Province of Drenthe now uses only a little compost in contrast to earlier days. Forestry uses in southern sections are still very important because forest litter is bought by Belgium (for azalea raising near Ghent) and compost can replace the forest litter.

Only 4% of the compost is used on grazing lands because it is not needed to maintain humus in grasslands. Those farmers so using it do so because they observed that cattle have a better appetite for grass so treated (perhaps certain mineral deficiencies are counteracted by compost). Horticulture uses little compost in general because green manuring and mulching can provide the requirements for soil organic matter.

Compost use in poultry raising did not increase in 1959 and comprises 1.9% of the total. Although most consumers were pleased with results, some complain of excessive moisture and turning labor during winter and excessive drying and dustiness in summer. These difficulties could be eliminated, however, by mixing with other materials such as straw, peat, waste or freshly cut grass. Compost is in increasing use in pigpens and achieves good results (with a few shovelfuls daily per pen). The proportionate use for this purpose is still small.

The year 1959 was a very good one for the compost market with demand greater than production. If this trend continues (we believe it will be), greater production of compost will be desired and new composting plants required.

4. A New Composting Process for Refuse and Sludge--The Tollemache System.

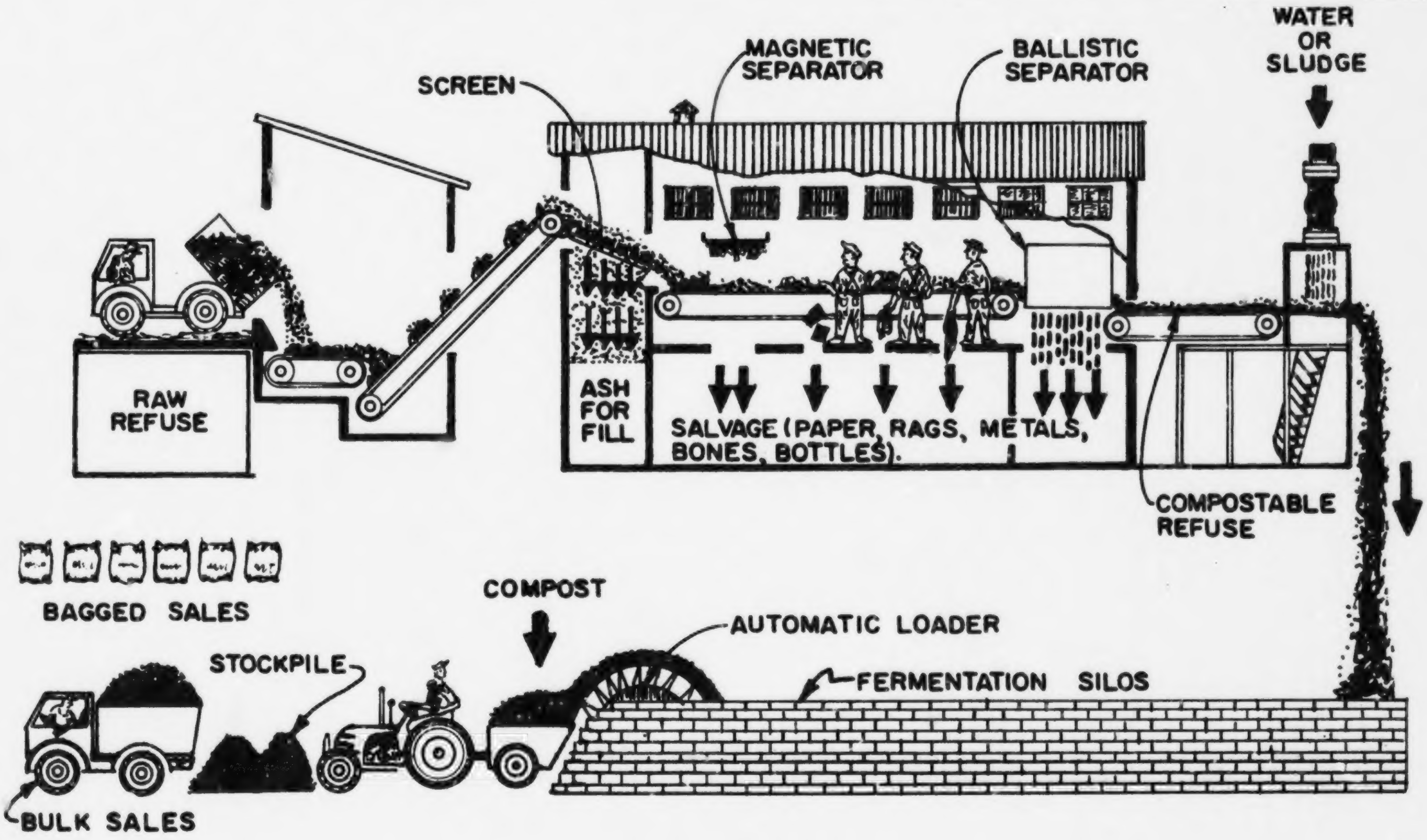
The Tollemache process, as developed at the refuse composting plant at Mabelreign (Southern Rhodesia), is described in the following (see drawing):

Refuse preparation: Refuse passes on a conveyor from the bunker to a screen for ash removal, then on another conveyor where the first magnetic separation and hand sorting to remove salvage and discard items are accomplished. A ballistic separator removes glass fragments and rocks. After the addition of water or sludge, the compostable material is discharged into composting chambers.

Composting: The fermentation "silos" or chambers have masonry walls open at the top and a perforated concrete floor which permits forced aeration. From time to time the compost is mixed and simultaneously pulverized by a traveling turner-mixer (similar to a rotary cultivator). This procedure is repeated until the compost leaves the chambers. After two weeks in a chamber, refuse compost has the following typical analysis:

Organic matter	58%	Phosphorus (as P_2O_5)	0.7%
Moisture	about 50%	Potassium (as K_2O)	1.1%
Nitrogen	1.4%	C/N	20

The cost (calculated for Africa) is about 15 shillings ($2.10)/ton of compost for a plant with a capacity of 40 tons of compost/day. The manufacturer is the Composting Company of Rhodesia, Ltd., Member of the John Laing & Son Group of Companies, Salisbury, Southern Rhodesia.


WATER OR SLUDGE
SCREEN
MAGNETIC SEPARATOR
BALLISTIC SEPARATOR
RAW REFUSE
ASH FOR FILL
SALVAGE (PAPER, RAGS, METALS, BONES, BOTTLES).
COMPOSTABLE REFUSE
BAGGED SALES
COMPOST
AUTOMATIC LOADER
STOCKPILE
FERMENTATION SILOS
BULK SALES

SCHEMATIC DIAGRAM - TOLLEMACHE SYSTEM

DHEW-PHS-CDC

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5. Household Waste Disposal. I. Some Microbiological Aspects of Organic Waste Disposal with Special Emphasis on Cellulose Digestion by William D. Gray, The Ohio State University. Abs. from "Rhodesian Engineer", pp. 30-33, Sept. 1959.

Decomposition transforms insoluble organic matter to soluble forms readily available to a great variety of microorganisms. Virtually all organic substances can be destroyed by one or more microorganisms in time. Cellulose comprises about 50% of the dry weight of plants and is the most abundant organic compound in the world. Therefore, decomposition of organic matter is mainly a matter of decomposition of cellulose.

Like starch, cellulose is a high molecular polysaccharide built up of glucose units. As a result of the greater resistance of the glucose combinations in cellulose to enzyme attack, it is more difficult to break down than starch. Some fungi digest cellulose well but cellulase, the cellulose-digesting enzyme, is not nearly as widespread as amylase, the starch-digesting enzyme.

In the composting process conditions should be arranged to favor the growth of cellulose-digesting fungi. Mixed wastes decompose in stages, the more readily decomposable matter first. The first stage should be aerobic and involve thermophilic bacteria to decompose sugars, starch, protein and hemicellulose and to kill insects, worm eggs and pathogens.

After the first stage there remains largely cellulose and lignin which favor development of fungi if the moisture content is maintained at about 60% and good aeration is provided. The temperature should not be too high because at the maximum attainable temperature no fungal growth occurs.

6. Household Waste Disposal. II. Mabelreign's Household Waste Disposal Problem by D.H.L. Keeble. Abs. from "Rhodesian Engineer", pp. 33-39, Sept. 1959.

An insanitary open, burning dump was used by the Town of Mabelreign for refuse disposal. Other methods were considered and composting was selected because of the low soil fertility in the area and for economic reasons. An analysis of the refuse for a week from the town (6,900 population) revealed:

Total amount:	47,080 lb.	Density:	11 lb./cu.ft.
Bottles:	3.2 %	Bones:	0.5 %
Metal:	4.1 %	Paper and Cardboard:	9.2 %
Rags:	1.0 %	Remainder:	81.7 %

A new untried process, the Tollemache system, was tested in a pilot plant and selected as the preferred composting process. The Town Board approved a contract with performance guarantees for construction of a 30 T/week plant.

Process stages are: receiving and storage (1 day), sorting, magnetic separation, paper and tin baling, addition of raw sewage, "silo" composting, and compost maturing in heaps. The "silo" consists of a horizontal concrete chamber with a perforated floor, a rail-mounted turner-agitator, and forced aeration through the floor. Two chambers were built at Mabelreign and one turner operates in both of them.

The plant was accepted in May 1959 and functions satisfactorily except that non-compostable materials, such as polyethylene and milk bottle caps, are objectionable. It is planned to add a "silorator" which will cut up such material and blow the compost 40 to 50 feet to a stockpile. Compost sales are good at 70 S/ton at the plant or 1 d/lb. in bags. Salvage sales have not been as high as expected and there is no market for rags or tins. The plant cost 5,600 pounds sterling and, with buildings, accessories and land totalled 10,600 pounds sterling. Operating costs and receipts are not yet stabilized. Compost temperatures reach 150°F.

7. Discussion Corner
(Editors assume no responsibility.)

A contribution by Engineer Kortleven, Institute for Soil Fertility, Groningen, the Netherlands:

In (the German version of) the article "The Reclamation of Refuse at Budapest" in IRGR Bulletin 9, it was reported that only 14% loss of organic matter occurred after 40 days of composting. This 14% is the difference between the initial (51.5%)and the final (37.4%) contents of organic matter on a dry weight basis. (Ed. note: These values were shown as 55.3% and 37.4% in the English version based on recalculation.)

In my opinion this method of calculation gives an incomplete picture of the loss of organic substances; the calculation should have been made as follows: We assume that the absolute weight of ash remains the same (throughout composting). Based on an equal weight of ash, the following amount of organic matter remains after 40 days:

$\frac{41.5}{62.6} \times 37.4 = 24.8\%$ The loss is therefore 51.5-24.8 = 26.7% with reference to the total (dry) weight of the initial material. With reference to the total weight of organic matter in the initial material, the loss is therefore 52%. (Ed. note: The initial ash content in the German version was shown as 41.5%; the recalculated value in the English version was shown as 44.7%.)

If the organic matter is determined by loss on ignition and the unburned carbon in the ash is not taken into consideration, then the loss is even greater than 52% (approximately 67%).

In our opinion it would be very valuable if a uniform method of calculating loss in organic matter is used--that is, the loss of organic matter from that initially present.

In the table on page 6 (German version) the over-all carbon content amounts to exactly 52% of the organic matter content. This infers that the carbon content was calculated and was not determined by analysis. It thus appears that the C-N ratios shown in the table are open to question. (Ed. note: Because the wet and dry weight values presented in the German version of the above table were obviously not calculated correctly, the editor recalculated and corrected the dry weight percentages assuming the wet weight values to be correct in preparation of the table on page 4 of the English version. Thus, for an initial organic content on a wet basis of 26.6% and a moisture content of 51.9%, the initial content of organic matter on a dry basis should be: $\frac{100(26.6)}{100-51.9} = 55.3\%$, not 51.5% as shown in the German version. Similarly, the initial ash content would be 44.7%, not 41.5%. The editor agrees with Mr. Kortleven that the loss in organic matter is considerably greater than shown by the original author and verifies his calculation of 52% loss based on the values given in the German version.)

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INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)

Information Bulletin No. 11

June 1961

1. Does Aeration Accelerate the Composting Process? A research report from the Heidelberg composting plant, by Otto Horstmann and Egon Engelhorn, edited by Dr. Georg Farkasdi.*

Introduction: The great amount of refuse being ground in the rasping machine at the Heidelberg composting plant requires a very large area for the windrows. The problem is to determine how best to speed up the decomposition. The effect of aeration by one or more turnings or by bored air holes and of the height of windrows on decomposition rate were studied. Large-scale experiments were conducted on the grounds of the Heidelberg plant. The practical test methods and limits of their variation had to be established. Possible hindrance of the studies by the variable composition of the refuse needed consideration. The last question was immediately answered in the negative. Processing refuse in the rasping machine yields a well-mixed homogeneous material.

The experimental methods were presented as recommendations, titled "Betriebskontrolle" (process control), after discussion by the Arbeitsgemeinschaft für kommunale Abfallwirtschaft (AkA) (Work Group on Municipal Wastes).

Methods of Study: Variations in aeration of compost windrows were achieved by:

a. Smaller windrows (less self-compaction, better aeration).

b. Boring of air channels (diameter 30 cm, depth 150 cm, distance apart 40 cm). /Ed.note: the latter distance is questioned; it appears to be quite small./

c. Several turnings (up to 3 times).

Moisture content of the raw ground refuse was adjusted to about 45% by addition of water; the pH was between 6.2 and 6.5.

Figure 1 shows the layout of the 16 experimental windrows. The windrows in rows 1 and 2 were 3m high and 6m wide, those in rows 3 and 4 were 1.5m high and 4m wide; the length was uniformly 12m. Turnings were as follows: 1st after 8-20 days, 2nd after 50-80 days, 3rd after 110-150 days.

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*Baurat Otto Horstmann, Stadtwerke-Fuhrpark, and Egon Engelhorn, Stadtwerke-Kompostanlage, Vangerowstrasse 59, Heidelberg; and Dr. Georg Farkasdi, Institut für landwirtschaftliche Mikrobiologie, Landgraf Philip Platz 4,Giessen, Germany.

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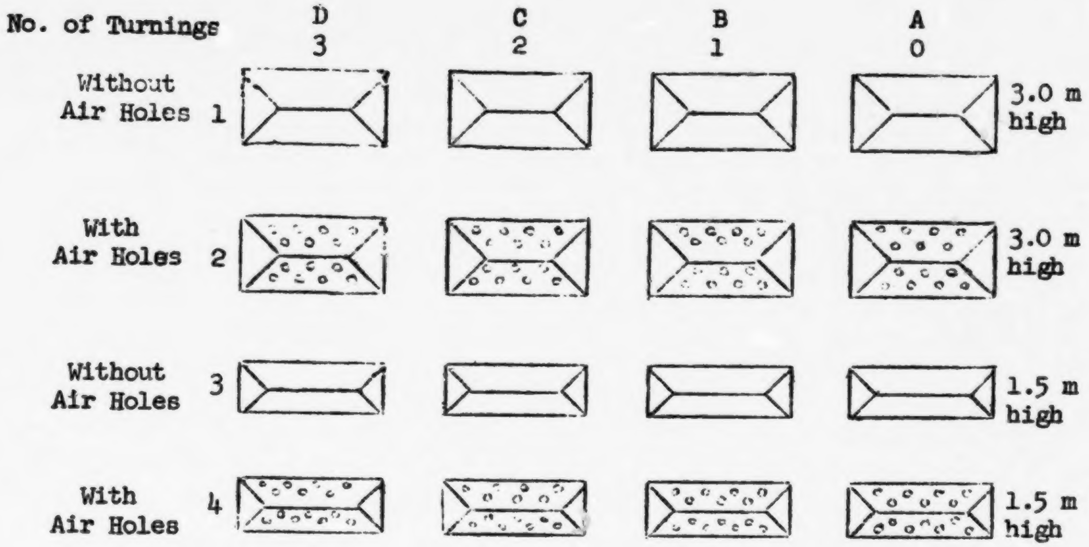
Figure 1

EXPERIMENTAL COMPOSTING WINDROWS



Methods of Determination: This report cannot include all of the results of the physical, chemical, and biological analyses. Only those giving the more reliable information on the maturity of compost and suitable for practical use are included.

Aerobic decomposition (with aeration) is desired in the composting of organic materials. In contrast to this, anaerobic digestion, or so-called putrefaction, occurs in the absence of air. This decomposition proceeds more slowly and produces less heat; the heat is insufficient to destroy pathogens, parasites, and weed seeds. Other disadvantages are foul odors, vermin infestations, etc.

In aerobic decomposition the high molecular weight organic compounds are broken down by the enzymes of microorganisms and then are either converted to cellular substance or oxidized with the help of atmospheric oxygen. The released energy is converted partly to heat. The final products of aerobic decomposition are water, carbon dioxide, and inorganic compounds. Temperature and CO_2-content are also considered measures of biochemical decomposition, although with certain limitations.

Air circulation within the compost piles, including the diffusion or accumulation of heat and carbon dioxide, has still not been determined accurately. The temperature and CO_2-content can be measured but not the actual production of heat and CO_2 in the individual layers of the pile. Conclusions may be drawn, however, from these measurements regarding the rate of decomposition (1).

A sharper increase in temperature and CO_2-content indicates more intensive decomposition of organic matter. The study results are based on these findings with the above mentioned limitations. With increased decomposition of organic matter, the composting material is decreased. The pile gradually consolidates by its own weight, decreasing the pore volume and increasing the density. Measurements of these may thus be included in the evaluation of the decomposition process (2).

Screening the compost separates it into various fractions of different particle size; the proportion of finer fractions is greater and of coarser fractions lesser in the more completely decomposed material. Sieve analysis therefore gives certain indications regarding the progress of decomposition.

Temperature measurements were made at four locations and at various depths (10-200 cm) with bimetallic probe thermometers. Carbon dioxide contents were also measured at four sites in each windrow, in the 3m high piles at 1.5 and 2m depths and in the 1.5m piles at 0.75m depth. In this determination a tube with hooded opening in the end is inserted in the pile and the gas mixture withdrawn into an Orsat-Fischer apparatus (absorption in potassium hydroxide) by means of a vacuum pump.

Particle size determinations were conducted on an average sample from four sites in each experimental windrow, from the 3m high piles at 80 and 160 cm depths and from the 1.5m high piles at 60 cm depth. Samples were taken after about 5 months of composting, dried at 85-95°C, and fractionated by dry sieving. Density and pore volume were determined on the same samples at the Institut für Bodenkunde und Pflanzenernärung, Geisenheim, by the methods of analysis commonly used there (3).

Results: Temperature--the general course of temperature, the rate of its increase (comparison of values on the 7th, 20th, 40th, and 120th days), the maximum temperature, and the duration of exposure to certain temperature ranges (above and below 55°C) were measured.

The general course of temperature was found to be similar to that observed in the usual composting of refuse (4). Heating occurred in all parts of the windrows. During the first week there was a steep rise in temperature; high temperatures persisted for 6-10 weeks and then gradually subsided. Cooling occurred rapidly in the outer layers while interior temperatures were recorded for as long as 120 days in the 45 to 65°C range.

Temperature rise differed with depth in the windrows. Table 1 shows that the highest temperature at 30 cm depth occurred after 7 days with temperatures being about 10° lower at 80 cm depth and 16-20° lower at 120-140 and 200 cm depths. This relationship remained about the same to the 20th day. Based on the variations studied, the following conclusions are drawn concerning the rate of rise in temperature:

Effect of size in windrows: Temperatures at all depths in the larger windrows were higher than those in the smaller windrows to about the 40th day. Then the temperature was higher at 80 cm depth in the small windrows than at 30 and 120-140 cm depths in the large windrows. This tendency extended to the 120th day. As a rapid increase to above 60°C quickly stops microbial decomposition (most active at 45-50°C), temperature conditions for decomposition were more favorable in the smaller windrows during the first month. No correlation could be established between turning and the rate of increase in temperature.

As shown in table 2, a definite correlation existed between rate of temperature increase and the presence of aeration channels. In piles with air holes, temperatures increased more slowly at 30 and 80 cm depths, probably as a result of increased diffusion of heat. The reverse was true in the deeper portions of the pile where temperatures rose faster and remained higher during the entire study period because the air channels permitted increased oxygen uptake. Turning the windrows one or more times (groups B, C, D) negated the influence of the air holes but the association is not very clear.

Table 3 shows the highest temperatures (69-72°C) at 80 cm depth, next the exterior and the 120-140 cm zones with 64-66°C, and lowest the bottom (200 cm) of the larger windrows with an average of only 55°C.

The effects of windrow size and of turning on peak temperatures reached are shown in table 3. While an influence on maximum temperature caused by turning was not evident in the larger windrows, it was clear that the more often the turning of the smaller windrows the higher the temperature at all depths.

The average values in table 4 indicate lower peak temperatures at 30 and 80 cm depths, caused by greater diffusion, but higher temperatures about 2-5°C at 120-200 cm depths as a result of the air holes. This confirms the observations concerning the rate of increase in temperature.

Table 1

Correlation Between Rate of Temperature Increase and Size of Windrows

Day	Windrow	Height, m	Average Temperature, °C at Depth, cm:			
			30	80	120-140	200
7	A-B-C-D/1&2	3.0	63.9	54.5	46.6	46.6
	A-B-C-D/3&4	1.5	62.6	52.9	43.8	----
			-1.3	-1.6	-2.8	----
20	A-B-C-D/1&2	3.0	61.5	56.6	52.3	48.0
	A-B-C-D/3&4	1.5	58.3	55.6	49.6	----
			-3.2	-1.0	-2.7	----
40	A-B-C-D/1&2	3.0	57.6	63.3	60.2	51.0
	A-B-C-D/3&4	1.5	56.5	64.1	58.2	----
			-1.1	+0.8	-2.0	----
120	A-B-C-D/1&2	3.0	42.4	53.9	55.8	47.2
	A-B-C-D/3&4	1.5	37.5	56.1	54.2	----
			-4.9	+2.2	-1.6	----

Table 2

Correlation Between Rate of Temperature Increase and Aeration Channels

Day	Windrow	Air Holes	Average Temperature, °C at Depth, cm:				
			30	80	120	140	200
20	A/2&4	Present	55	58	48	57	51
	A/1&3	Absent	57	59	50	54	48
			-2	-1	-2	+3	+3
40	A/2&4	Present	48	62	61	65	61
	A/1&3	Absent	59	64	54	63	52
			-11	-2	+7	+2	+9
120	A/2&4	Present	24	53	60	60	52
	A/1&3	Absent	36	55	59	56	47
			-12	-2	+1	+4	+5

Table 3

Correlation Between Peak Temperatures and Number of Turnings by Size of Windrows

Windrow	Height, m	Number of Turnings	Maximum Temperature, °C at Depth, cm:		
			30	80	120-140
A-1	3.0	None	65	69	64
A-3	1.5	None	61	65	59
			-4	-4	-5
B-1	3.0	One	68	69	67
B-3	1.5	One	64	69	60
			-4	0	-7
C-1	3.0	Two	67	69	63
C-3	1.5	Two	67	72	62
			0	+3	-1
D-1	3.0	Three	65	68	68
D-3	1.5	Three	67	80	74
			+2	+12	+6

Table 4

Correlation Between Peak Temperatures and Aeration Channels

Windrow	Height, m	Air Holes	(Max.) Average Temperature, °C at Depth, cm:			
			30	80	120-140	200
A-B-C-D/1	3.0	Absent	66	69	66	55
A-B-C-D/2	3.0	Present	65	66	68	60
			-1	-3	+2	+5
A-B-C-D/3	1.5	Absent	65	72	64	---
A-B-C-D/4	1.5	Present	64	69	67	---
			-1	-3	+3	---

The effect of windrow size on the duration of exposure to given temperature ranges is shown in table 5 for the two non-aerated windrows (A-1 and A-3). Comparison shows that the larger windrow exhibited greater duration of exposure in the high-temperature range at all depths than the smaller windrow. However, this appears to be only the result of heat retention in the larger windrow, not of more intensive decomposition. Studies with plants grown in pots*containing

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*These tests were conducted with rye as the experimental plant by the method of Neubauer. Evaluation included germination, growth, and color of the plants in addition to total production of organic matter. [Ed. note: presumably the latter is total plant weight.]

Table 5

Correlation Between Temperature Duration and Windrow Size

Windrow	Height, m	Average Duration, days, in Specified Temperature Range:							
		Below 55°C at Depth, cm:				Above 55°C at Depth, cm:			
		30	80	120-140	200	30	80	120-140	200
A-1	3.0	40	12	22	124	84	112	102	0
A-3	1.5	99	26	84	--	24	97	39	--
		+59	+14	+62	--	-60	-15	-63	--

[Ed. note: The German and French bulletins show the temperature ranges reversed in this table; they were changed above to correspond to statements made in the text.]

Table 6

Correlation Between Temperature Duration and Aeration Channels

Windrow	Ht., m	Air Holes	Average Duration, days, in Specified Temperature Range:							
			Below 55°C at Depth, cm:				Above 55°C at Depth, cm:			
			30	80	120-140	200	30	80	120-140	200
A-B-C-D/1	3.0	Abs.	104	120	81	4	34	18	57	134
A-B-C-D/2	3.0	Pres	38	77	104	28	99	60	34	110
			-66	-43	+23	+24	+65	+42	-23	-24
A-B-C-D/3	1.5	Abs.	66	116	63	--	73	23	76	--
A-B-C-D/4	1.5	Pres	29	97	80	--	110	42	59	--
			-37	-19	+17	--	+37	+19	-17	--

the two composts confirmed this hypothesis in that plants grown in compost from windrow A-3 surpassed in every respect those grown in in compost from A-1. No effect could be detected as a result of the number of turns on the duration of exposure in a given temperature range. Also, there was no influence indicated by additional aeration as a result of the provision of air holes.

Fewer days were experienced in the higher temperature range at shallow depths (30-80 cm) and more days at deep depths in windrows with air holes (table 6). The effect of air channels is reversed with depth as they prolong high temperatures in the deeper regions of the piles. The same cause already mentioned, regarding rate of temperature increase and maximum temperature, seems to explain this phenomenon.

Carbon Dioxide-Content: The CO_2-content of the (air in) individual windrows shows a fairly uniform curve. Soon after piling, sometimes in a few hours, intensive CO_2 production occurs -- up to a maximum of 80% by volume. /Ed. note: This is written as "Vol. %" throughout the foreign language versions./ The highest content is attained at a pile temperature of about 45°C (113°F) (see table 7). As temperatures increase, the CO_2-content rapidly decreases, falling to 10-20% by volume in 3 or 4 weeks at temperatures above 60°C. This reduction is only slightly changed in the windrows with air holes. However, in windrows without air channels the CO_2-content does not increase when the temperature has declined.

Comparison of maximum CO_2-content of large and small windrows shows an average of 8-15% by volume higher values in the middle of the large piles as compared to the small. This does not, however, indicate more extensive decomposition but rather retention of this relatively heavy gas. The increasing CO_2-content with depth supports this hypothesis. Results of the pot experiments after Neubauer also confirm this conclusion.

Table 8 shows the average CO_2 values for each month of the tests (from individual values obtained every 10 days) as well as the grand averages from which the effect of aeration by turning and by providing air holes may be compared. There is a marked and permanent reduction in CO_2-content after the first month of composting in all zones of all windrows. In the middle zones, 75 cm depth in the small and 150 cm depth in the large windrows, the influence of turning is apparent. For example, the average CO_2-content is 50 to 90% higher in the large piles after 2-3 turns than after 0-1 turn. In piles turned several times the regression of CO_2-content was considerably retarded, particularly during the 2nd and 3rd months and even at a depth of 200 cm. Additional oxygen supply thus activated the aerobic microbial processes. The CO_2 increase, despite increased opportunities for its diffusion, represents a real increase in CO_2 production. Frequent turns of the small windrows exerted no such effect; these piles appeared to be adequately aerated without being turned.

The effect of additional aeration through air holes was the same in both groups; the CO_2-content was reduced. If the results of pot trials are also considered, showing better plant growth in compost from windrows with air channels, the reduced CO_2-content is due to increased diffusion rather than to decreased production in this case.

Table 7

Correlation Between Maximum CO_2 Content and Temperature

Windrow	Ht., m	Air Holes	Average CO_2, %, and Temperature, °C, at Depth, cm:					
			75		150		200	
			CO_2	°C	CO_2	°C	CO_2	°C
A-B-C-D/1	3.0	Abs.	--	--	69	43	74	42
A-B-C-D/2	3.0	Pres.	--	--	70	47	75	49
A-B-C-D/3	1.5	Abs.	61	42	--	--	--	--
A-B-C-D/4	1.5	Pres.	55	47	--	--	--	--

Table 8

Correlation Between CO_2-Content and Aeration by Turning of Air Channels (Monthly Average CO_2-Contents at Mid-Depth

Windrow	Ht., m	Air Holes	No. Turns	CO_2-Content, % by Vol., by Month:					Avg.
				1	2	3	4	5	
A-1	3.0	Abs.	0	43	15	15	12	--	21
B-1	3.0	Abs.	1	42	15	12	15	14	20
C-1	3.0	Abs.	2	54	30	34	25	13	31
D-1	3.0	Abs.	3	47	32	30	28	12	30
Average: A-B-C-D/1				47	23	23	20	13	25
A-2	3.0	Pres.	0	36	9	7	6	--	15
B-2	3.0	Pres.	1	32	11	9	8	5	13
C-2	3.0	Pres.	2	52	24	27	8	7	24
D-2	3.0	Pres.	3	46	23	27	16	15	25
Average: A-B-C-D/2				42	17	18	9	9	19
A-3	1.5	Abs.	0	39	17	20	16	--	23
B-3	1.5	Abs.	1	41	25	22	23	17	26
C-3	1.5	Abs.	2	44	29	27	18	15	27
D-3	1.5	Abs.	3	39	29	30	25	15	28
Average: A-B-C-D/3				41	25	25	21	16	26
A-4	1.5	Pres.	0	42	13	12	12	--	20
B-4	1.5	Pres.	1	37	16	11	12	10	17
C-4	1.5	Pres.	2	47	25	24	13	6	23
D-4	1.5	Pres.	3	36	22	23	13	11	21
Average: A-B-C-D/4				41	19	18	13	9	20

Particle Size: Not all results of the sieve analyses are presented. Figures 2 and 3 are graphical examples showing the correlation between aeration and particle size. They show the coarsest fraction (above 4mm) because particle-size reduction best characterizes increased decomposition of the organic matter. Similarly an increase in the finest fraction (0-1mm) would show increased decomposition.

Figure 2 shows that the proportion of coarse particles decreases with an increased number of turns in both large and small windrows giving a negative correlation. If the two extreme variants of the experiments are compared (A - not turned, D - turned 3 times), as in figure 3, with and without air holes (in the larger windrows 1 with 2, in the smaller windrows 3 with 4), the reduction in coarse particles in piles with air channels is clearly shown.

Pore Volume and Density: The results given in table 9 show the effect of supplemental aeration on the pore volume and density. The effect of turning is very marked in the windrows without air holes; the pore volume decreases and the density increases with increased number of turns. The effect of air channels is less marked. At depths of 60 and 80 cm, the windrows with air holes yielded slightly smaller pore volume and higher density; but, at the 160 cm depth, no influence of air channels is evident.

Summary: Experimental results with ground refuse from Heidelberg showed that supplemental aeration improved windrow composting. In the smaller (1.5m height) windrows the material packed less, air circulation (admission of O_2, escape of CO_2) in the pile interiors was greater, the temperature increased more slowly, stayed longer in the range below 55°C that is favorable for decomposition, and did not rise as high as in the larger (3.0m) windrows. Particle size, pore volume, density, and Neubauer pot trials indicated that more intensive decomposition occurs in the smaller than in the larger windrows.

Because of area limitation, large cities with high refuse yield have to avoid small windrows in composting. The experiments showed the advantages of small windrows to be slight; while decomposition probably occurs somewhat faster in 1.5m windrows than in 3.0m windrows, the increased space required is not offset by the decrease in time of composting. If a plant must use 3.0m high windrows due to lack of space, provision must be made for supplemental aeration.

Frequent turning of windrows accelerates decomposition more than the provision of air holes. While air channels provide certain composting benefits, particularly in unturned windrows, their action is largely confined to a depth of 100 cm. They therefore cannot substitute for turning. Tests

Figure 2

INFLUENCE OF TURNING ON PARTICLE SIZE

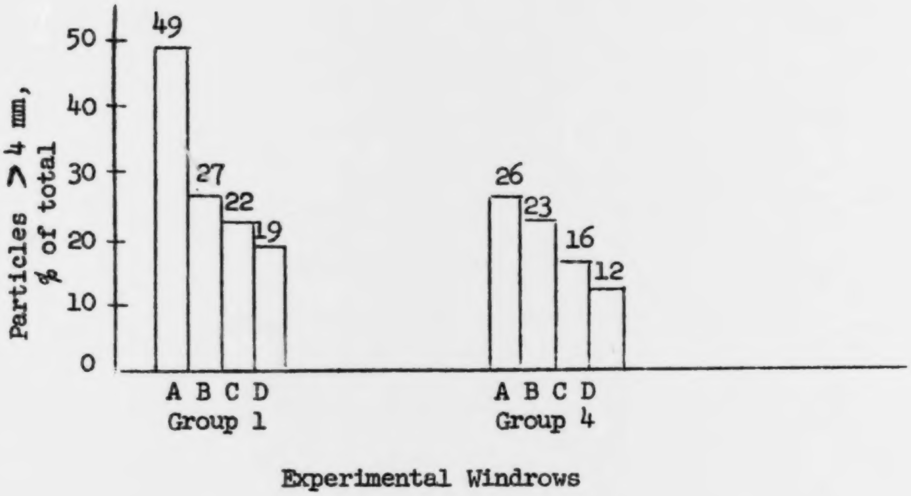

Figure 3

INFLUENCE OF AIR HOLES ON PARTICLE SIZE

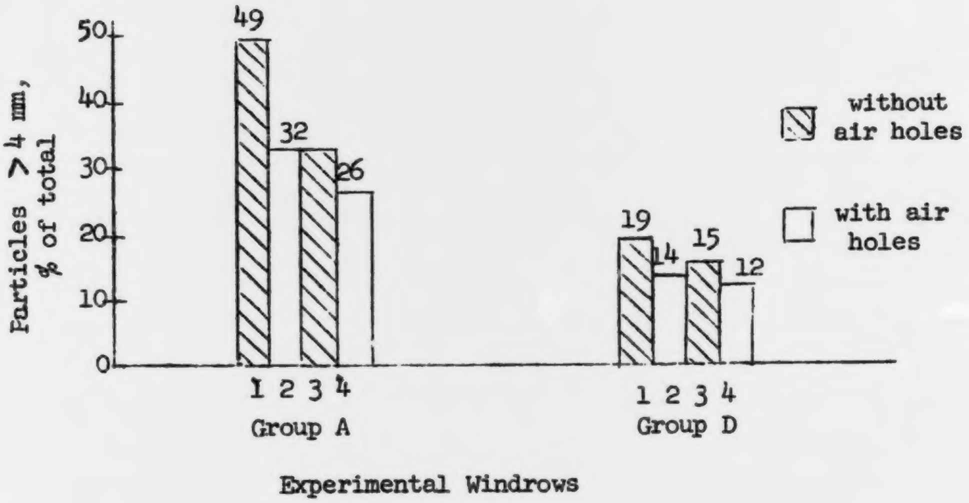

Table 9

Correlation Between Aeration and Pore Volume and Density of Compost.

Windrow	Ht., m	Air Holes	No. Turns	Pore Volume at Depth, cm:		Density at Depth, cm:	
				80	160	80	160
A-1	3.0	Abs.	0	81	77	32	39
B-1	3.0	Abs.	1	72	75	47	42
C-1	3.0	Abs.	2	71	71	49	49
D-1	3.0	Abs.	3	67	63	56	63
Average: A-B-C-D/1				73	71	46	48
A-2	3.0	Pres.	0	73	76	45	40
B-2	3.0	Pres.	1	76	79	41	35
C-2	3.0	Pres.	2	67	72	57	48
D-2	3.0	Pres.	3	67	62	56	64
Average: A-B-C-D/2				71	72	50	47
				at Depth, cm:		at Depth, cm:	
				60		60	
A-3	1.5	Abs.	0	84		26	
B-3	1.5	Abs.	1	74		44	
C-3	1.5	Abs.	2	71		50	
D-3	1.5	Abs.	3	67		55	
Average: A-B-C-D/3				74		44	
A-4	1.5	Pres.	0	78		38	
B-4	1.5	Pres.	1	69		52	
C-4	1.5	Pres.	2	71		50	
D-4	1.5	Pres.	3	66		57	
Average: A-B-C-D/4				71		49	

(Ed. note: The units of measurement for pore volume and density are not given in this report. Inasmuch as all values exceed 50, it is assumed that pore volume of uncompacted composting material is the total porosity, measured in per cent by volume. It would therefore not be free air space which is usually less than 50%.

Density is weight per unit volume or bulk weight of the uncompacted materials. As density values of ground refuse might be in a range of 10-50 lb/cu ft or 160-800 g/l, it is assumed that the values shown in table 9 are in terms of g/100 ml. It is then also the per cent of the density of water.)

at other plants show also that air holes rapidly become plugged, thus their effect is of limited duration. The relatively slight advantage of air channels should be weighed against the labor cost for their provision.

Advantages of two or three turns of the smaller windrows were also slight. Turning generally increased intensity of decomposition as measured by increased CO_2 production, reduction of coarse and increase of fine particle fractions, reduction of pore volume, and increased density. The sanitary aspects of turning include the destruction of pathogenic microorganisms and weed seeds, which might survive in the outer layer, by subjecting them to higher temperatures.

References:

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c. Knickmann, E. - Kleines Praktikum der Bodenkunde und Düngerlehre für Fachschule und Beruf. Stuttgart, 1958.

d. Straub, H. - Kompostierung städtischer Abfallstoffe -- Erfahrungsbericht vom Kompostwerk Baden-Baden. Gesundheits-Ingenieur (77) 312, 1956.

2. Studies of the Effect of Windrow Height on Composting Rate by B. Teensma, Engineer, Amsterdam.

The required area for composting plants often plays a very important role. After the refuse has been ground it must be piled for decomposition (in the windrow process). Paper constitutes a greater part of the organic matter in domestic refuse and consists of cellulose having about 50% carbon and no nitrogen. However, the microorganisms that decompose paper require nitrogen for the production of protoplasm, which they obtain from their surroundings. During microbial decomposition, oxygen and carbon unite to form carbon dioxide which escapes. Thus, the carbon-nitrogen ratio (C/N) becomes smaller and smaller during refuse decomposition. It amounts to about 35 in fresh refuse; it should be reduced to about 20 or less during normal composting. If compost is applied to the soil too soon or insufficiently ripened, the microorganisms continue decomposition and withdrawal of nitrogen, an occurrence detrimental to the plants grown in the soil.

It follows that at least 40% of the carbon in refuse must be converted to CO_2 before it can be said that the compost is mature. It was found at Schiedam that a C/N of 20 is attained in windrows 1.5m high with a single turning and a composting time of 8 weeks. Because variation in refuse composition and in weather conditions greatly influences the decomposition process, the composting time for 1.5m windrows should be at least 12 weeks. A further period of 4 weeks is added to insure that the C/N is less than 20.

A large area is therefore required with windrows of 1.5m height and a composting time of 12 weeks. One must also remember that no compost is used for greater or lesser intervals in summer and winter! A composting area of more than one hectare (2.5 acres) is required for a city of 100,000 population. An area this large is not always available and some cities have asked us if it is possible to use windrows 3m high without thereby impairing the quality of the end product.

Experiments were conducted by Dr. F. C. Gerretsen in an attempt to solve this problem. Two windrows of well-mixed, homogeneous refuse were formed at Schiedam on September 24, 1958, one 1.5m high, the other 3m high. Both were turned on November 3 and composting was ended on December 23, after 3 months. The analyses revealed a few interesting points which are briefly discussed here.

Because of a heavy rain on the night of September 23-24 the moisture content of both piles was higher than normal; the fresh refuse, spread in a thin layer, became completely soaked. Moisture in the final product was 55% which was 15% higher than normal. The high moisture content without doubt caused more anaerobic decomposition than would have been the case under normal conditions. This was apparent both on turning and later when the compost was hauled away. In addition to the normal brown compost on the outside and black compost inside, there was a lower layer about 10 cm thick containing a gray-green, very wet, compressed material. This "green compost" contained 3.4-3.9% butyric acid and released a very unpleasant odor! One never finds such gray-green compost in windrows with a normal moisture content.

Temperatures: The interior temperature increased to 40°C within a week; a week later it was 57° in the large windrow, 52° in the small. Maximum temperatures, reached in the third week, were 59° in the large and 53.5° in the small windrow. The temperatures then gradually declined, somewhat more slowly in the large than in the small pile. At turning time, after 6 weeks, temperatures were 56° and 44°, respectively. Temperatures increased again in both windrows after turning on November 3.

The second peak temperatures were reached on December 10 at 65° in the large and 46° in the small pile. After turning, the temperatures averaged 15° higher in the large windrow than in the small for the following reasons:

a. Insulation is better in the large windrow and therefore the heat loss is less.

b. Less organic matter was decomposed prior to turning in the larger windrow and thus a greater supply of nutrients existed for the decomposing bacteria, causing increased activity.

The temperatures were higher in both piles at a depth of 50 cm than at greater depths (better aeration). Temperature was 71° in both windrows at this depth on October 3. Also at 50 cm depth the temperature in the small pile fell faster and was consistently 10° less after turning than in the large pile. At the end the temperature was still 60° in the large and 47° in the small windrow at 50 cm. The reason for lower temperatures at greater depth than 50 cm is a more anaerobic decomposition with less heat production.

Gas Analysis: By means of a specially constructed tube, gas samples were taken from the windrows initially daily, later semi-weekly, and still later weekly. They were tested for O_2, CO_2, H_2 and CH_4. Samples were taken from several depths each time.

As early as 24 hours after the start all of the oxygen had been consumed. Considerably more carbon dioxide was found in the large than in the small pile -- 39.1 and 40.1% in the large, 16.6 and 24.1% in the small (duplicate tests). This proved that an anaerobic condition had already developed in the interior of the large windrow. Indeed, only 20% CO_2 can ever be found under aerobic conditions because only as much CO_2 is formed as O_2 is consumed and this corresponds to the O_2-content of the air. If more than 20% CO_2 is found, the excess must be the result of anaerobic processes. The energy needed for microbial life is then obtained by reduction of O_2-containing chemical constituents (such as iron compounds) and of organic compounds (such as cellulose), with CO_2 formation in the absence of atmospheric O_2. It is logical that gas diffusion in the center of the large pile is less than that of the small. This was demonstrated by recovery of only 18.5% CO_2 at a 40 cm depth in the large pile in the absence of both methane and hydrogen.

On September 26 (2-day) at 120 cm depth in the large pile, the values were 58.5-62.0% CO_2 and 29-40% H_2. The same contents were found in the small pile only a day later. On September 30 no more hydrogen could be found in the small windrow (diffused to the atmosphere); two days later this was true in the large windrow. After October 2 the gas compositions of the two were practically the same; H_2 and CH_4 were not found and O_2 only in very small amounts (about 1%). This indicates that adequate outside air was diffused to the interior. Further confirmation was found in that in the small pile the $CO_2 + O_2$ averaged 20% (varied from 17.7 to 23.2%) while in the interior of the large pile the average was 27.4% (only 20.3% at 50 cm depth). As would be expected, anaerobic decomposition was more widespread in the large than in the small windrows, but not to the extent that all entrance of new oxygen was prevented.

Considerable development of hydrogen occurred in the first 5-7 days. This is associated with strong anaerobic decomposition which then stopped abruptly. Dr. Gerretsen believes that this condition developed because there occurred a violent decomposition of putrescible carbohydrates such as sugar, starch and hemicellulose. The decomposition is so rapid that there is simply not enough oxygen available to permit aerobic conditions. The decomposition of cellulose only occurs, at a more leisurely pace, when these substances have largely been broken down and there is enough oxygen available to permit predominantly aerobic action. This is shown by the finding of only traces of hydrogen and no excessively high contents of CO_2 immediately after turning (a similar condition to the initial windrowing).

On November 6, 3 days after turning, free oxygen was almost entirely consumed in both piles. Only in the hot zone at 50 cm depth in the large windrow was there oxygen to be found, indicating an aerobic condition. This was also true at the higher temperatures (59° in the center, 70° at 50 cm depth on November 22).

No hydrogen or methane, or very insignificant amounts, were found after turning. The CO_2-content was then quite low (18.3 - 23.7%), as low as 14.9% in the hot zone. It increased gradually and reached a maximum of 46.2% in the center of the larger windrow on November 17, and a period of intensive anaerobic decomposition continued until December 6. The CO_2-content was considerably lower (24.1%) on December 13; the decomposition intensity had subsided presumably because most of the readily decomposable matter had been broken down.

Anaerobic action was less intensive in the interior of the smaller windrow (maximum CO_2 was 38.3%) apparently because a greater portion of the organic matter had been decomposed before turning.

It follows that the periodic gas analyses provide a good picture of the course of the bacterial processes. The method used for obtaining the samples did not disturb the interior of the piles in any way.

Laboratory Tests of CO_2 Production: Samples were taken initially, upon turning on November 3, and at the conclusion on December 23, including samples by depth and composite samples. Carbon dioxide production from all these samples was measured for 23 days (each time with 100 g of material -- dry weight). The more important results were as follows:

The raw material produced 32,500 mg of CO_2 and production was continuing after 23 days. The composite samples from the windrows produced 15,500 mg of CO_2 from the large and 10,500 mg from the small. It follows that the compost from the smaller windrow was more decomposed in 3 months than from the larger windrow.

The brown, aerobic compost in the outside layers of both piles produced 8,000 mg of CO_2 while the black, moderately anaerobic compost produced 9,000 to 18,000 mg according to depth. The deeper the sample, the less "ripe" was the material and the greater the CO_2 production. The gray-green, highly anaerobic compost, found only in small amounts in the base of the windrows, produced 22,000 mg of CO_2. In the laboratory this material was initially overgrown with a heavy layer of mold fungi (lower pH value because of the presence of butyric acid). This compost was the least decomposed of the three. Pot experiments with these composts in 1959 showed that the green compost exerted a definite ill effect on plant growth. Unexpectedly, it was not the brown aerobic compost that gave the best results but the black compost. It appears that a certain degree of anaerobic decomposition improves the quality of the compost but the extent of this anaerobic decomposition should be determined.

These investigations showed that increasing the height of piles obviously does no harm and may be desirable provided good drainage is provided and the compost in the bottom is not too wet. Strong anaerobic action, combined with the formation of butyric acid, is to be avoided.

3. Report on Recent Results at the Refuse Composting Plant at Küsnacht-Zürich (Bühler Hammermill combined with Dano Egsetor Plant) by Dr. R. Stahel, M.D., Küsnacht.

The requirements that must be met by a composting plant of a medium-sized town with limited available space are defined:

a. The plant should process all refuse, if possible, including that from households, gardens, and perhaps from small industries.

b. Regular combined collection should be made, avoiding special trips.

c. Haul should not be long, that is, the plant should be near the center of population.

d. The proportion of discarded materials should be kept as small as possible so that dumping sites for them can be used for a long time.

e. Non-composted matter should be as inoffensive as possible in esthetic and hygienic respects (no fires, few rats, no danger of water pollution).

f. The compost must be satisfactory, without injurious materials (such as shards), and must possess as much active organic matter as possible.

g. Composting time should be as short as possible to require a minimum of area.

h. The plant should be able to process the sewage sludge of the community.

i. Plant costs should not be too high, the equipment sturdy and subject to few breakdowns, and operating costs low.

The community of Küsnacht, which also includes that of Erlenbach (16,000 population, final construction to serve 35,000 population), hopes to come a step nearer these ideal conditions with their plant. As the Küsnacht plant is the first of its kind, we will describe it and the future plans. Although the process has been in operation only a few months, certain useful indications of some practical importance have shown up.

The plant consists of a two-stage Bühler hammermill and a single Dano mixing drum, without a biostabilizer. All mixed refuse, with the exception of large pieces of metal, cloth, chemicals and liquids, are dumped into a bunker. From the bunker the material runs on a conveyor belt to the coarse mill. Along the belt is a check point set at a load of 300 kg to insure uniform feeding of the mill. Large pieces of metal, previously missed, are removed from the conveyor.

First grinding occurs in a coarse hammermill, alternately driven by one of two 63 HP electric motors with automatic controls. The starting input is 250 kw and the operating input is 80-100 kw. This mill has 16 reversible hammers and runs at 1200 rpm. It must operate at high speed to avoid balling and, because of rapid passage, there is little moisture loss during milling.

Following the coarse grinder, the iron is removed by a magnet and the remaining material passes to the fine grinder wherein two rotors run in opposite directions. Each rotor has 24 hammers, one runs at 3000 rpm, the other at 1500 rpm. Each hammer can be used 4 times. This pulverizes the material, particularly breaking up glass, bones, and stones.

After the fine grinder, the material is conveyed by chain conveyor to a bunker and from there by belt conveyor into the Dano egsetor. Water is added to give a moisture content of about 70%; later sludge at 70% moisture content may be mixed in. The material is mixed in the Dano unit in a very short time; substances such as plastic and rubber are eliminated. (Ed note: The egsetor also screens as well as mixes the pulverized refuse.) The fresh compost is then piled (in windrows). The hauling and stacking are done with a crane. Windrows are turned after a few weeks with a Jabelmann "Fräslader" (Ed. note: This is a self-propelled loader). The loader has proved outstanding in assuring rapid and more certain decomposition.

A few results, after a short period of operation, are:

a. There is surprisingly little noise as the mills are rubber mounted.

b. Dust is almost completely eliminated by enclosures.

c. Operating capacity:

   (1) Mill: 22 cu m/hr with input of 80-100 kw.

   (2) Egsetor: about 10-15 cu m/hr according to the amount of residue. The egsetor operates more hours than the mills. As the sewage plant is just being put in operation, we have had little experience with sludge addition. At present 70-80 cu m of refuse per day are being processed (5 day week).

d. Hammer wear:

   (1) Coarse mill: after 200 hrs,* one-third the hammers (5 or 6) should be replaced.

   (2) Fine mill: rotor at 3000 rpm -- after 160 hrs* in summer or 80 hrs in winter (wearing due to ashes) 24 hammers (1 set) require replacement; rotor at 1500 rpm -- hammers last five times as long.

(*Ed. note: These values are from the German version; the French version says "after 2000 hrs" in both cases.)

e. Electrical consumption: 6 kwh/cu m of refuse, including heat, light and crane operation (about 20 kwh/metric ton of refuse).

f. Personnel: two men suffice for all operations, including windrowing and loading compost trucks.

g. Discard: about 3% of discarded material must be disposed of. The metal goes directly to a junkman and is not included in the 3% (metal content about 2%).

h. Equipment costs:

	Year	Swiss francs	U S. Dollars
Dano plant	1952	156,000	36,300
Hammermills, incl. electrical installation	1960	180,000	41,900
Crane	1954	12,000	2,800
Jabelmann loader	1959	15,000	3,500
		363,000	84,500

The cost of buildings and land is not included as it varies with the community.

i. Probable operating budget (per year):

Salaries and social security	26,000	6,050
Hammermill maint. cost, provisional	5,200	1,210
About 60,000 kwh at 8 centimes	4,800	1,120
	36,000	8,380

j. Plant hazards: What cannot be processed or can be processed only with some difficulty?

(1) Large pieces of metal: Steel cannot be ground, the plant automatically stops. But massive damage to the hammers occurs, perhaps even to the hammer arms (repair time about 2 hrs).

(2) Rags can "tie up" the machine just as the Lilliputians tied up Gulliver (disentangling time about 15-30 min).

(3) Grinder clogging, such as bridging over the throat or clogging of the grates, must be prevented by smooth feeding to prevent overloading or stoppage. A rapidly moving conveyor-feeder assures smooth grinder operation and prevents ball formation.

(4) Damage to the coarse grinder housing may occur due to high speed impact of heavy pieces. Mill walls should be protected by sheet steel 8-12 mm thick.

(5) Condensed moisture, present after each operation of the mills, should be removed by thorough aeration or it will result in corrosion or balling.

Future plans: Sewage sludge will be mixed (with the ground refuse) according to the suggestions of EAWAG. Küsnacht yields a relatively dry refuse containing mostly paper (60-70%). Mixed refuse amounts to about 3 l/cap./day, sewage sludge at 70% moisture content about 0.25 l/cap./day. There thus exists a ratio of 12:1 by volume, 4:1 by weight. Investigations of EAWAG indicate that good decomposition occurs even at 2:1 (refuse:sludge by weight).

We hope to be able to process all the refuse and sludge in one plant at the same time making available to gardeners a high value material, free of hard particles, and with the good fertilizer and humus qualities demanded by intensive gardening. We are grateful to the IRGR at the EAWAG for their advice.

4. The Refuse Treatment Plant of the Baden-Brugg Region by Th. Zambetti, Director of Public Works, Baden (Aargau).

Smoke, vermin and noxious odors are disadvantages accompanying open refuse dumps and constantly cause public nuisances. Also, suitable dumping areas are becoming scarcer in thickly settled regions. The greatest hazard is possible contamination of our drinking water. That which was scarcely recognized as a problem for 200 years today requires immediate attention to avoid extensive damage.

This problem has arisen in a number of communities in the Baden-Brugg region. Recognizing that joint effort was required, 10 communities joined for this purpose, first: Baden, Brugg, Ennetbaden, Obersiggenthal and Wettingen, then shortly: Killwangen, Neuenhof, Turgi, Windisch and Würenlos. Based on thorough studies and on visits to native and foreign refuse processing plants, it was decided to build a composting plant of the SMG/Multibacto process. This system, developed by the Schweizerischen Metallurgischen Gesellschaft (Swiss Metallurgical Corp.), Basel, and by Wartmann & Co., Brugg, enjoys all modern technical advantages. The Firma Multibacto AG, Basel, together with an American laboratory, has developed the biological portion of this process. (Ed. note: the Earp-Thomas process). The company is also concerned with compost sales and has established a good organization for marketing.

The plant, constructed under the supervision of Engineer E. Holinger, is being placed in operation. The equipment, installed in a modern building, is able to handle the refuse from about 100,000 population, and capacity will be doubled later. As soon as the nearby sewage treatment plant (towards Limmat) is completed, sludge will be processed with the refuse.

The refuse arrives in Ochsner trucks and is dumped in a large bunker with conveyor floor which transports it to the grinding plant. Iron and tin cans are removed by a magnetic pulley and are baled for delivery to a steel plant. The refuse then passes into a large, specially constructed multirotor grinder (capacity 15 tons of refuse) which grinds such hard materials as glass, stones and pottery and shreds such tough substances as textiles, plastics and leather. Large items, such as boxes, cartons, crates and packing materials arriving separately at the plant, are fed through a chute directly into the grinder. Ground refuse is conveyed vertically to an overhead hopper and then to a sieve. The fines are discharged beneath the sieve to a bunker provided with an automatic regulator and discharge device. As the fine refuse leaves the bunker it is inoculated with a special bacterial mixture and mixed with water or, later, with sludge. The material finally arrives at the SMG Multibacto digester built by Wartmann & Co. This tower, about 6m diam. x 9m high, contains several stories and a central shaft with plow arms. The material is constantly mixed, rotated and aerated and automatically dropped from the top to bottom story. By regulation of temperature, oxygen addition and moisture, ideal conditions are set up in the digester to promote both natural and added bacteria of decomposition in the material. With an inconceivably rapid proliferation of the various microorganisms, whereby several billion are simultaneously active in 1 g of material, a more active decomposition process is attained. The bacterial activity develops temperatures of 60-70°C, providing a process similar to sterilization, so that the compost is absolutely satisfactory as to hygienic requirements. In the bottom story a partial drying occurs due to moisture evaporation. After 24 hours the refuse is fit for use as compost which resembles forest soil in structure and appearance.

A bucket elevator discharges the compost to a sieve which separates it into fine compost and mulch. The few remaining large pieces are reground. Sieved compost is conveyed to a storage room where it is stored in containers or bagged for shipment to consumers. Chemical fertilizers, such as nitrogen, phosphorus and potash, may be added by a battery of mixers to enrich the compost for greater nutrient action of crops. The end product is not untested. The association of companies have operated a large-scale research plant for about 3 years at Muttenz, near Basel, at which compost is produced from refuse and is, in part, fortified as just described. The products are successfully sold to about 1500 Swiss consumers. The association had partly given up trying to sell the compost produced at the Turgi plant because it requires a vast organization and a special consultant service. It has turned over all sales to the Firma Multibacto AG which has organizational facilities for such sales.

Our refuse composting plant is currently producing more compost than all of the other Swiss composting plants combined. It is also the first plant to use all of the refuse in composting except iron, requiring no dumping or burning of residue. Open air composting piles, with all their attendant sanitary and aesthetic disadvantages, are not needed in our process. Dust removal equipment insures no dust hazard in and near the plant. The entire process is completely automatic and is conducted in a modern building in a sanitary manner. Surprisingly few workers are needed to operate a plant of such large capacity. Space requirements are very low in proportion to yield and future expansion.

Plant costs were about 2 million Sw. fr. after deduction of Canton (County) grants. These were financed by a public loan (bond) secured by the communities involved. Administration, operation, maintenance, amortization and interest are to be financed pro rata by the communities, preferably based on weight of refuse processed. The cost per ton depends on the amount processed; initially this was about 15 Sw. fr ($3.50) based on 11,000 tons of refuse. Municipal budgets should also include refuse haul costs. Records are maintained by the City Accountant of Baden; the Public Works Dept. of Baden assumes technical supervision.

The group of communities hopes that this plant will not only solve the refuse disposal problem in the Baden-Brugg region but also lead work in this field so that the refuse is not burned but transformed into a valuable soil builder for gardening, viniculture, agriculture and forestry. In this way a remedy has been found for the depletion of soil humus which results from decades of application of chemical fertilizers.

5. Communications from the Secretariat.

Methods for the Examination of Refuse- and Refuse-Sludge-Composts (January 9, 1961).

It has been shown many times in papers and discussions on refuse composting that research results are not described in the same terms. If the methods of analysis used are not completely described, it is often impossible to interpret results of analyses performed by a foreign laboratory. Fruitful research in our field is only possible if results and conclusions are expressed in terms of the same common denominator. To achieve this purpose, uniform methods of analysis are needed. Standard Methods of Analysis have attained this goal internationally in the field of water supply and purification.

We reported at the First International Congress on Disposal and Utilization of Town Refuse (the Netherlands, 1959) that the Federal Institute (Swiss) for Water Supply, Sewage Purification and Water Pollution Control (EAWAG) in Zurich was working on a compilation of methods of analysis to distribute to those interested. This collection is now complete and a preliminary draft is prepared. These methods have all been tested in the Division of Refuse Research of our Institute and are used regularly by our laboratory. It is not yet complete and we will continually supplement it.

We intend to hold a symposium in 1961 at Zurich* to which we will invite as many national experts as possible in the field of compost analysis to discuss these suggested methods. We hope it will be possible in this field to achieve a uniformity of investigative techniques.

(*Ed. note: Later word indicates that the symposium will be held in conjunction with the Second International Congress at Essen, Germany, in May 1962.)

Second International Congress of IRGR.

The Second International Congress of the IRGR will be held in May 1962 at Essen, Germany. Bulletin 12 will give details of this meeting.

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Bockelmann, W. (1960):	Feste Abfallstoffe - ein brennendes Problem. (Der Städtetag, Vol. 13, No. 11).

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Krohn, H.-R. (1960): Diskrete Müllabfuhr. (Der Städtetag, Vol. 13, No. 5).

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INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)

Information Bulletin No. 12

September 1961

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1. Ten Years of Soil Improvement with Peat, Refuse and Sludge by Dr. M. Trinel, Professor Emeritus, Berlin-Wannsee.

"Refuse", a heterogeneous mixture of rubbish with a greatly varying composition according to source, size of city, living habits of the people, and the time of year, must be removed by the municipal administration. The problems created are quite different in individual cases, but are consistently complex in all instances due to the variation in individual ingredients.

In addition, large quantities of sewage are discharged from municipal dwellings entailing great expenditures for sanitary disposal. Night soil and sewage have been used for fertilization and irrigation for thousands of years, particularly because of their high nutrient content due to the high level of nourishment of man. Before there was a fertilizer industry, wastes and sewage were of interest to agriculture. The voluminous work of Robert Somerville(1), appearing in 1795 in London, thoroughly discussed the refuse and waste waters of English "industries" of that period possibly suited for making types of fertilizers, including such wastes as bones, oil cake, horn shreds, malt dust, wool and leather wastes, tanbark, flax steeping water, soap ashes, potash, kelp, limestone, gypsum and common salt.

The many wastes from industrial and commercial operations, from urban households, and from municipal sewage treatment plants are quite often irrationally treated in many civilized countries, possibly excepting the Netherlands, due to excessive disposal costs:

a. because of technical difficulties, and

b. because of high haul costs, particularly in large cities.

Refuse dumping results in well-known hazards to health: ground water pollution, vermin attraction, and production of dust and unpleasant odors. Various processes have been developed here and abroad to avoid these hazards, designed for either burning or biologically oxidizing refuse from widely divergent sources as economically as possible. A focal point of interest of city administrations for some time has been the agricultural use of both mineral and organic wastes in order to reduce disposal costs by incineration or by composting. No true profit appears in the realm of present possibilities.

The fertilizing action of wood ashes was well known in ancient times; Virgil in his Georgica, Vol. 1, Verse 80, gives the following instructions which, in the translation by Voss (German), reads: "Insofar as you (would) replenish the exhausted field, strew it all over with restorative manure or dirty ashes." The first scientist in modern times who became interested in the utilization of human wastes was the Dutchman, Jan Ingen-Houss(2).

Use of domestic refuse, however, was considered (first) by cities at the end of the 19th century. J. H. Vogel reported in the Deutschen Landwirtschaftlichen

Presse in 1895 on the use of city refuse. H. Thiesing published in the Deutschen Landwirtschaftlichen Gesellschaft in 1902 on research concerning "Die landwirtschaftliche Verwertung des Hausmülls" (the agricultural utilization of domestic refuse). But only in 1921 were the recommendations first widely applied. Then in Havelland's marsh, west of Berlin, 2100 hectares of lowland moor were treated with refuse in amounts up to 3000 cwt/ha* to raise the land surface above the ground water, in many cases standing only 50 cm beneath the surface.

A report by O. Heuser, now professor at the Biologischen Bundesanstalt, Brunswick, appeared in 1921(3). Preliminary research by Heuser, using Berlin refuse that had been piled 6m high for 8 years, showed equivalent fertilizing action on potatoes, cabbages, hemp, sugar-beets and turnips as commercial fertilizers when applied at 200 cwt/ha on 23 hectares. Moreover, the quality of the hemp was greatly increased, apparently due to improvement in structure and reaction (pH) of the marsh soil. Much success was achieved in raising Boghara clover (Melilotus alba), cabbage, and turnips directly on the refuse heaps without further fertilization. Yield reductions occurred only in cases where the marsh soil was rendered alkaline by the refuse (at about pH 8.0), particularly in the case of hemp. Heuser's extensive field trials led to the large application (3000 cwt/hectare) on the lowland moors near Berlin, the compost being transported by a light railway.

In 1960, after 40 years, the author inspected these areas and took soil samples. Our physical and chemical tests showed an exceedingly favorable effect of the rotted refuse on the soil structure (friable) at depths of up to 40 cm (see table).

In addition, the copper and zinc contents and the readily-soluble potassium (determined by the lactate method) showed that the surface soil had been improved and it is recognizable even today; these contents were 8, 2, and 12 times, respectively, that of the soil not treated with refuse. The boron content showed no difference.

The shards and other hard particles remained in the old refuse, as there were no separating machines in those days. These occasionally interfered with tilling and caused an ugly-looking seedbed. Even today, after 40 years, the glass shards reflect the light and the soils are appropriately named "Glitzerböden" (glittering soils).

In 1923 the Meliorationsamt at Zürich reported on "Verwendung von städtischem Kehricht" (utilization of /street/ sweepings). An essay by L. Migge appeared the following year in Meliorations-Ingenieur on "Die Praxis der kommunalen Kompostwirtschaft" (the practice of municipal composting); also, a report by J. Bodler on "Düngungsversache mit Feinmüll" (fertilizing experiments with fine refuse). Then many publications appeared on the agricultural uses of refuse (see Bibliography).

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* 1 cwt (hundredweight) = 100 kg; 1 ha (hectare) = 10,000 sq. m.

Sieve Analysis

One kg samples of fresh lowland moor soil from Hertefeld

Particle Size	Without Refuse	With Refuse
Surface:	Sample 4	Sample 7
Larger than 30 mm	13.3%	6.4%
15-30 mm	25.9%	9.4%
7-15 mm	40.0%	17.7%
3.7 mm	15.7%	36.2%
Smaller than 3 mm	5.0%	30.2%
At 40 cm depth:	Sample 5	Sample 8
Larger than 30 mm	21.7%	2.3%
15-30 mm	19.7%	11.9%
7-15 mm	36.1%	22.5%
3-7 mm	12.4%	34.7%
Smaller than 3 mm	10.2%	28.3%
At depth greater than 40 cm:	Sample 6	Sample 9
Larger than 30 mm	78.4%	79.8%
15-30 mm	12.5%	10.0%
7-15 mm	6.6%	6.7%
3-7 mm	1.4%	2.6%*
Smaller than 3 mm	0.8%	1.3%

[*Ed. note: This value was shown as 22.6% which was obviously in error.]

1. Problems: Peat, refuse and sludge contain appreciable nutrients but oppose the higher nutrients of chemical fertilizers by their soil-building effect through favorable changes in soil properties such as: water retention capacity, absorption, reaction, and introduction of trace elements. This is an important economic factor with the public because the actions can develop in particularly poor soils for their improvement.

The question of prolonged activity [lasting effects] is of vital interest because it is easier and cheaper to obtain nutrients from mineral fertilizers than from composts. Thus, our 10-year field trials should answer the question as to how long the soil-improvement effects are maintained in light soils.

2. Methods: Field trials were conducted from 1947 to 1957 on plowed wasteland in collaboration with the Institut für Ernährungsforschung, Rehbrücke (Director: Prof.-Dr. Scheunert). The soil was nutrient-poor, water-permeable, alluvial sand of weakly acid reaction that had originally been a pine woods. A field area, 80 x 25m, in the Nuthe lowlands, just south of the Autobahn, on which poorly developing winter rye had been plowed under, was divided into four 500 sq m plots. Soil samples were analyzed from each plot at the beginning and end of the trials. Soil classification is shown in table 1.

Table 1

Soil Classification	Depth beneath surface, cm.				
Core sample no.	1	2	3	4	5
Sand with a little raw humus	0-60	0-60	0-60	0-60	0-60
Lighter sand with rust particles	60-100	60-90	60-90	60-100	60-90
Rust-colored, sandy condensation-zone	100-115	90-120	90-130	100-115	90-120
Damper, grayer, more impenetrable sand (gley-like)	115-290	120-280	130-295	115-300	120-300
Ground water level	300	300	300	300	300

The soil is thus a sandy podzol gley*; the test plots are similar in soil type, layering, and ground water level. Calcium carbonate was not found in any sample. The usual crop rotation in the farming by the Instituts für Ernährungsforschung (Agent: Mr. Rohwetter) continued during the entire experiments. The test plots were subdivided into three parts, each 167 sq m and the three parts of plot 1 served as controls for the initial experiments of 1947 as shown in table 2.

Table 2

Plot (500 sq m)			
1	2	3	4
Untreated	Peat waste	Rotted Refuse	Sludge
Red beets, potatoes, turnips	Red beets	Potatoes	Turnips

In 1949, in order to simplify tilling, the types of cultivation and crops were so changed that an experimental crop could be grown in corresponding subdivisions (167 sq m) of the plots. For further simplification in 1950 and later years only one crop was grown on all plots. Table 3 shows the planting sequence.

*/Ed. note: "Podzol" - a gray, leached, acid soil containing very little clay. "Gley" - a soil in which water-logging and lack of oxygen have caused the material to be a neutral gray in color./

Table 3

Year	Crop planted on:			
	1 Untreated	2 Fresh peat	3 Rotted Refuse	4 Sludge
1947	Red beets, potatoes, turnips	Red beets	Potatoes	Turnips
1948	Oats, Winter rye, potatoes	Oats	Winter rye	Potatoes
1949	Winter rye summer rye, oats	Winter rye summer rye, oats	Winter rye, summer rye, oats	Winter rye, summer rye, oats
1950	Winter rye	Winter rye	Winter rye	Winter rye,
1951	Winter rye	Winter rye	Winter rye	Winter rye
1952	Lupine	Lupine	Lupine	Lupine
1953	Winter rye	Winter rye	Winter rye	Winter rye
1954	Serradella (birdsfoot)	Serradella (birdsfoot)	Serradella (birdsfoot)	Serradella (birdsfoot)
1955	Winter rye	Winter rye	Winter rye	Winter rye

Because of the high costs of products and their distribution, we did not repeat the field trials so that the experimental error could not be calculated. We assumed, therefore, that only a yield increase of more than 10% could be considered significant. In 1947 the 500 sq. m. plots were treated as follows:

Plot 1: No soil-improving agents.
Plot 2: 39 cu m of fresh, shredded peat from Krampnitz = about 780 cu m/hectare.
Plot 3: 21 cu m of sieved refuse, ripened in piles from northern Berlin = about 420 cu m/hectare.
Plot 4: 30 cu m of fresh sludge = about 600 cu m/hectare.

The loads were evenly plowed under.

Compositions in percent of dry weight were:

Constituent	Damp peat from Nedlitz	Refuse	Sludge
Nitrogen (total)	2.5	0.2-0.4	2-3.5
Potash (K_2O)	0.1	0.05-0.9	0.1
Phosphate (P_2O_5)	0.25	0.2 -0.3	0.2
Lime (CaO)	4.0	4-12	4-7
Gypsum	---	About 14	---

To eliminate as much as possible the effect of primary nutrients in the agents, all plots received a complete fertilizer, and in 1950 and 1951 small amounts of fresh stable manure (about 100 cwt/hectare). Mineral fertilizers applied are shown in table 4.

Table 4

Applied as:	Mineral fertilizer applications in kg/ha of pure nutrients:						
	1948	1949	1951	1952	1953	1955	1956
40% potassium salt	80	80	80	80	80	80	--
Super phosphate	36	36	36	36	36	36	--
Calcium ammonium nitrate	40	40	--	--	--	--	--
Ammonium sulfate	--	--	40	--	32	--	--

In 1950 all plots received 30 cwt/ha of marl.

3. Results: Results by years are given in table 4a, including the relative yields in terms of the control (untreated) plot. In 1954 the fields were flooded by high waters of the nearby Nuthe (River) so no crops could be harvested.

The drought of the summer of 1947 prevented planting of turnips, despite repeated attempts. The potato harvests of plots 3 and 1 were 128 and 120 kg, respectively, showing no increase in yield. The red beets on plot 1 died while those on plot 2 weighed 87 kg without leaves, showing significant improvement in water-retention capacity by the peat.

3.1 Effect of peat on yield: Table 5 shows the action of fresh lowland peat on the harvest relative to the control.

Appreciable yield increases due to peat were demonstrated, particularly with summer rye, up to about 4 years after treatment. Crops reacted differently to the application of peat, however, as no success resulted in the fifth year with lupine for unrecognized reasons. The after-effects decreased after the fifth year but were apparently still detectable even after nine years, as the rye planted in 1956 appears to show.

The average yield increase during the 10-year test period was 58%, excluding the leguminous crops /lupine and serradella/, the behavior of which requires special discussion.

3.2 Effect of Decomposed Refuse on Yield: The action of this amendment may be followed in table 6.

Table 4a

Yields in Soil Improvement Experiments in Rehbrücke
1947-1956

Soil Amendment	1948 Winter rye			1949 Winter rye			1949 Summer rye			1949 Oats			1950 Winter rye		
	Kg	Cwt ha	Rel. %	Kg	Cwt ha	Rel. %	Kg	Cwt ha	Rel. %	Kg	Cwt ha	Rel. %	Kg	Cwt ha	Rel. %
None	16	3.2	100	128	25.6	100	33.1	6.6	100	24.1	4.8	100	40.0	8.0	100
Fresh peat	--	---	---	161.1	32.2	126	78.3	15.7	263	34.6	6.9	144	88.0	17.6	220
Mature refuse	156	31.2	975	116.0	23.2	91	37.7	7.5	114	66.3	13.3	275	75.0	15.0	188
Sludge	--	---	---	164.2	32.8	128	63.3	12.7	191	42.2	8.4	175	60.0	12.0	150

Soil Amendment	1951 Winter rye			1952 Lupine			1953 Winter rye			1955 Serradella			1956 Winter rye		
	Kg	Cwt ha	Rel. %	Kg	Cwt ha	Rel. %	Kg	Cwt ha	Rel. %	Kg	Cwt ha	Rel. %	Kg	Cwt ha	Rel. %
None	115	23.0	100	35.0	7.0	100	75.5	15.1	100	42.5	8.5	100	126.0	25.2	100
Fresh peat	168	33.6	146	33.0	6.6	94	72.5	14.5	96	48.5	9.7	114	134.5	26.9	111
Mature refuse	115	23.0	100	34.0	6.8	97	87.5	17.5	116	30.5	6.1	72	113.0	22.6	90
Sludge	165	33.0	143	30.0	6.0	86	83.5	16.7	111	30.0	6.0	71	127.5	25.5	101

1947 - No results because of unusual drought.
1954 - Plots were flooded for much of the summer is most test plantings rotted.

Table 5

Effect of Peat on Yields

Year	Crop	Relative Yield in % of Control
1948	Oats	No yield
1949	Winter rye	125.8
	Summer rye	263.5
	Oats	143.7
1950	Winter rye	220.0
1951	Winter rye	146.0
1952	Lupine	94.2
1953	Winter rye	96.0
1954	Winter rye	No harvest because of flooding.
1955	Serradella	114.1
1956	Winter rye	111.0

Table 6

Effect of Mature Refuse on Yields

Year	Crop	Relative Yield in % of Control
1947	Turnips	) No yield because
	Red beets	) of drought.
	Potatoes	106.0
1948	Winter rye	975.0
1949	Winter rye	91.0
	Summer rye	114.0
	Oats	275.0
1950	Winter rye	188.0
1951	Winter rye	100.0
1952	Lupine	97.1
1953	Winter rye	115.9
1954	Winter rye	No harvest because of flood
1955	Serradella	72.0
1956	Winter rye	90.0

The heavy application of refuse was extraordinarily variable in the different years. Thus, the yield increase for rye in the first year was 875%, for oats in the second year 175%, while that for winter rye was about 10% less and for summer rye about 13% more (than the control). Because of unknown limits of error, we assume that these values of 10% and 13% lie within the error of experimental limits. The various crops reacted differently; legumes appeared to be retarded by the amendment application.

In general considerable yield increases were indicated. The after-effect corresponds in time to that with peat but then appears to decline more rapidly. Omitting the legumes, the average yield amounted to 132%, this value being greatly influenced by the effect of the refuse during the second test year. The negative response of the legumes to this soil amendment cannot be explained. It is like the familiar unfavorable effect of the boron content of refuse.

3.3 Effect of Sludge on Yield. The relative effect of this material is shown in table 7.

Table 7

Effect of Sludge on Yields

Year	Crop	Relative Yield in % of Control
1947	No harvest because of drought	
1948	Potatoes	No yield
1949	Winter rye	128.2
	Summer rye	190.2
	Oats	175.0
1950	Winter rye	150.0
1951	Winter rye	143.4
1952	Lupine	85.7
1953	Winter rye	110.6
1954	Winter rye	(high water)
1955	Serradella	70.6
1956	Winter rye	101.0

Sludge also acted favorably; also here there was a sharp decrease in effectiveness of soil improvement after four years. The 10-year average increase in yield, excluding legumes, amounted to 43%. But the average yield increase of grain crops varied less extensively. After 6 years the yields balanced those of the control plot and the effect was ended. Legumes again reacted negatively far beyond the assumed limits of error of ± 10%.

3.4 Comparative Action of the Various Soil Amendments:

3.4.1 Effect on Yield: Considerable yield increases were obtained with the use of peat, refuse, and sludge, the over-all average amounting to 77.8%.

The decomposed refuse brought about the highest relative yields of 132%, but this varied extensively by years and was due largely to the big yield during the second year of testing. Even omitting this value, because of inability to compare with others for this year, the average yield increase over the 10 years is calculated to be 26%. The after-effect of refuse subsides more rapidly than that of peat. The soil-improving effect of peat resulted in a high average yield increase of 58%, predominantly due to its longer-lasting effects. The long-time action of sludge also is apparent here.

A point of emphasis is the consistent yield increases with all types of crops. It is further shown that, in years of unfavorable weather conditions and generally low yields, the increases in yield due to the soil amendments are particularly high. It follows that these soil amendments increase yields on light soils, particularly in unfavorable years, and therefore increase the certainty of returns from such soils.

Comparison of absolute yields with rainfall by months revealed a positive correlation between crop yield (particularly of winter rye) and the March-June precipitation, and a negative correlation between the yield and the July rainfall. There is no consistent relationship between total summer precipitation and yield, as was expected.

The duration of effectiveness of the soil amendments (average increase in yield of the three treated plots by years) as compared to that of the control is shown in table 8.

Table 8

	Years after Soil Amendments (Applied):							
	1 1948	2 1949	3 1950	4 1951	5 1952	6 1953	8* 1955	9* 1956
Relative increase in crop yield, %	--	67.4	86.0	29.8	--	7.5	--	2.0

*[Ed. note: Originally shown as 7 and 8]

Results for 1948 have not been used because only the refuse plot showed a yield (indeed, nearly 10 times that of the control). The above clearly shows the decline of after-effects of soil improvement agents along with use of complete fertilizers. Up to 4 years after amendments were added the yield increases were relatively high, then they diminished at varying rates.

3.4.2 Effect on Legumes: The reduced yields of the legumes require special consideration. The effect on yield of legumes 6 and 8 years, respectively, after applying soil amendments is not clear as table 9 shows.

Table 9

Relative Yield in % of Control:		
Amendment	Lupine	Serradella
Peat	-5.7	+14
Refuse	-3.0	-28.0
Sludge	-14.3	-29.4

The unfavorable effect on yield of legumes appears to increase in the order of peat-refuse-sludge although the effect is not always in accord. Peat, an exception, gave a slight increase (14%) in yield of Serradella, which may be considered as beyond the limits of error. No explanation can be given as to the cause of unfavorable action on the legumes. Relatively high boron, copper and zinc contents in refuse, which we first assumed to be responsible, can hardly be the explanation because peat and sludge also acted unfavorably.

3.4.3 Effect on the Soil: After completion of the experiments in the year 1958 samples were taken from individual plots; results of analyses are summarized in table 10 (averages from three samples).

The carbon content (after Kurmies) of the untreated plot was slightly increased due to regular plantings. The refuse and sludge plots showed about the same values, 0.8-1.0%. An appreciable increase was established only in the peat plot. It follows from this that the action of organic substances in the various amendments was maintained for 10 years only in the peat plot. Using a topsoil weight of 3 million kg/ha and the following characteristics of the peat:

1) C-content: 58% of the ash-free substance,
2) Ash content: 10% of the dry substance,
3) Bulk weight: 300 kg/cu m, and
4) Average moisture content: 50%,

carbon values may be computed over the ten year period for the peat plot:

	kg/500 sq m
1) C added in 39 cu m of peat waste	3000
2) Still present in the soil, 1958 (peat plot)	2100
3) Still present in the soil, plot 1	1200
4) C of the peat still present	800
5) C of the peat biologically decomposed in 10 years	2200

These assumptions, the differences in carbon content of the untreated plot and the peat-treated plot, reveal a biological decomposition of about 73%

Table 10

Soil Analyses After Long-Term Growing Tests

Constituent	Plot				
	Adjacent to Test Field	1	2	3	4
	Unfertilized	Complete fertilizer (N, P, K, Ca)			
	Untreated	Without Amendment	Peat	Refuse	Sludge
PH in n-KCl suspension	3.7	5.7	6.0	7.2	6.1
Organic matter, % C (after Kurmies)	0.64	0.8	1.4	0.8	1.0
Hygroscopic water, % (after Mitscherlich)	0.56	0.8	1.71	0.89	0.99
Max. absorption T-value in meg/100g	----	3.0	6.2	3.7	3.3
Basic deficiency T-S in meg/100g	----	1.4	1.6	0.0	1.1
Lime needed, cwt/ha CaO	32.0	12.0	14.0	0.0	9.0
P_2O_5 in mg/100g	9.5	13.6	11.4	22.1	18.6
K_2O in mg/100g	1.1	7.2	3.9	13.7	7.6

of the peat in 10 years. It follows that the carbon content may be easily increased by the use of peat, though in very large amounts (620 t/ha) [?] The effect of the organic matter of the sludge on the soil was no longer definitely demonstrable after 10 years while that of the refuse had completely disappeared.

The percent of hygroscopic water in the soil corresponds to the organic content because, due to the low moisture-retention of the sand in this case, moisture is almost entirely retained by the organic consistents. The peat plot showed the only increase in hygroscopic water. The maximum basic absorption (T-value) [cation-exchange capacity] of the untreated, refuse, and sludge plots showed no essential difference; only in the peat plot was this value appreciably increased. The pH value was shifted to neutralityonly in the refuse-treated plot. The acid soil reaction was favorably influenced in all plots by the 10 years of cultivation, more so in the case of the refuse plot. Peat exhibited the greatest lime-consuming action of the various amendments. Worth mentioning is the lasting effect of the refuse on retention of the lime content of the soil.

The P_2O_5-content was clearly increased in the refuse and sludge plots, as compared to the peat plot where reduction occurred. Potassium values changed similarly; they were somewhat increased in the refuse plot only, considerably reduced in the peat plot. Additional mineral content values were increased on all plots, least in the peat plot and most in the refuse plot.

Conclusions: The 10-year field test showed:

1) Soil physical properties (humus content, hygroscopic moisture, water retention capacity, absorption capacity) were particularly improved by the peat. Chemical properties, on the other hand, were improved over long periods particularly by the refuse and sludge.

2) Peat, mature refuse, and sludge, applied to poor soil, appreciably increased the yields of winter and summer rye, oats, and potatoes, and improved the certainty of yield in dry years, for prolonged periods (about 4 to 5 years).

3) These results, however, were obtained by the application of large amounts so, as a result of high haul and distribution costs of the soil amendments, refuse compost and sludge may be considered mostly for special crops, such as in gardening and viniculture. The high boron and copper contents of refuse must always be kept in mind for boron-sensitive plants to avoid reductions in yield.

4) The known unfavorable action of the amendments used on lupine and serradella cannot be explained; we may trace it to the high boron content.

5) These experiments confirmed the well-known fact that organic matter is rapidly decomposed in light soils.

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2. Composting Operation in Los Angeles County by C. R. Compton(1) and F. R. Bowerman(2). Reprinted with permission from: Compost Science 1 (4) 5-8, Winter 1961.

The Administrative and engineering staff of the Sanitation Districts of Los Angeles County has long been convinced of the practical and eventual economic feasibility of composting. The interest has been more than academic, in the sense that the Sanitation District's responsibilities have involved both sewerage and refuse disposal -- responsibilities which cover a land area of more than 660 square miles, having a population in excess of six million persons.

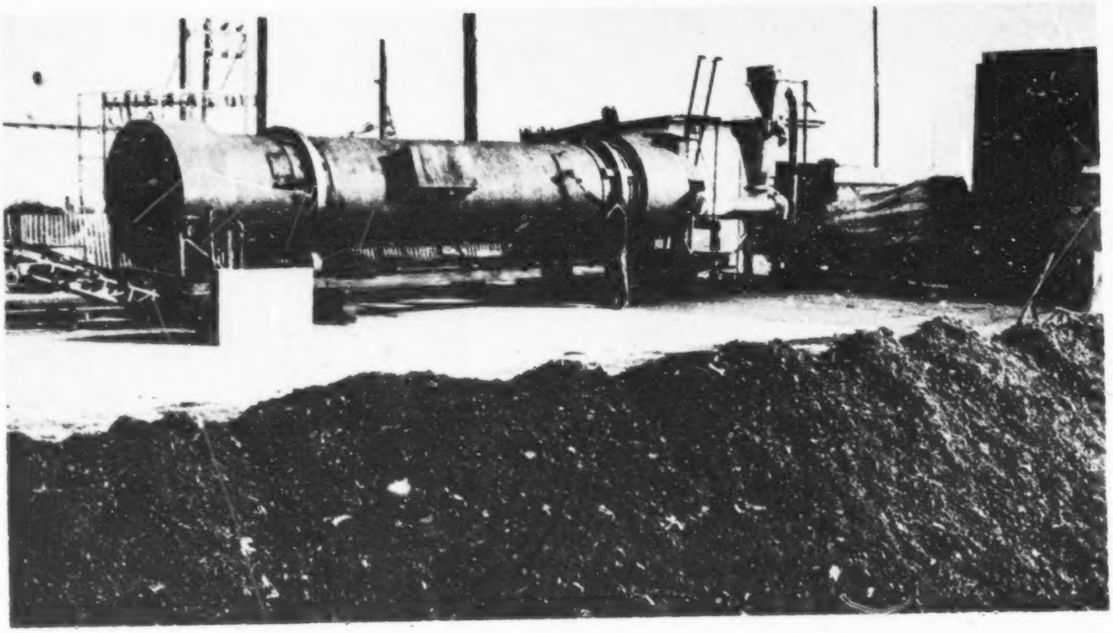
Currently, the Sanitation Districts are treating and disposing of about 270 million gallons daily of sewage and more than 3,000 tons daily of refuse. With more than 30 years of experience in sewerage and about ten years experience in refuse disposal, including the operation of major refuse disposal sites, the Districts have had opportunity to review the different ways in which composting might serve as a useful tool in their operations.

To the Districts, composting proffers several possible uses: one, as a means of salvaging some of the garbage and combustible rubbish now being disposed of at sanitary landfills or municipal incinerators; two, as a means of salvaging sewage sludge from sewage treatment plants, through odorless drying in composters, probably in combination with rubbish; three, for the composting and salvage of dewatered sewage and rubbish sludges resulting from the joint disposal of rubbish into sewers along with garbage and other sewage solids.

The first application under study by the Sanitation Districts involves the composting of combustible rubbish for direct production of compost as an adjunct to other refuse disposal activities. Composting in Los Angeles County can now only be considered as complementary to other disposal procedures. Unless and until major markets are developed for the sale of compost, little likelihood exists that composting will have much utility as a primary disposal procedure.

For example: In Los Angeles County (6,000,000 population), some 100 tons daily of dried, digested sewage sludge are packaged and sold as a humus-like soil conditioner, with perhaps another 100 or more tons of similar product imported for local sales through nurseries. By contrast, about 10,000 tons daily of organic refuse are being disposed

(1)Chief Engineer and General Manager and (2)Assistant Chief Engineer, County Sanitation Districts of Los Angeles County.



Cover picture - Experimental composting plant, Los Angeles County Sanitation Districts

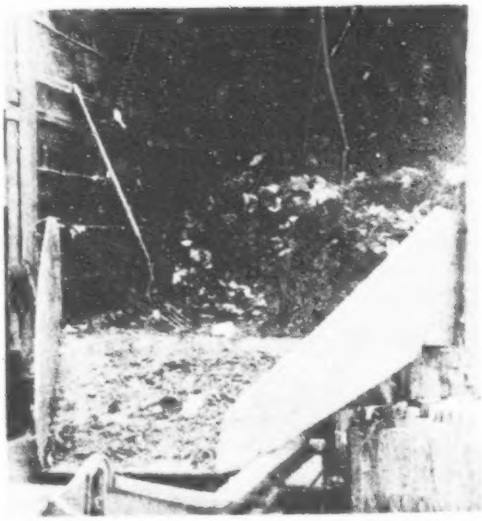


FIGURE 1. The rubbish used in the composting is hauled to the composter from the Sanitation Districts' Refuse Transfer Station. The raw material comprises about two-thirds paper and cardboard and about one-third grass, leaves, branches, and other woody material. The ratio of C/N is too high for this material to readily decompose in the composter without the addition of sewage sludge.

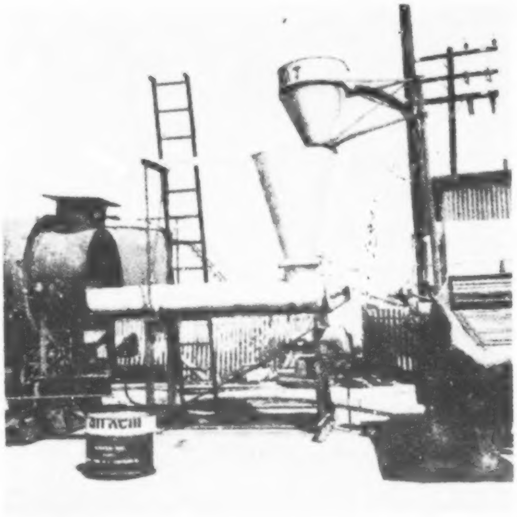


FIGURE 2. An alfalfa grinder at the extreme lower right of the picture grinds the rubbish, which is then blown into the cyclone at upper center where it falls by gravity into the feed hopper where a screw conveyor carries the ground rubbish into the feed-end of the composter. The feed-end of the drum is actually tightly closed; the open metal ring was part of the previous installation.

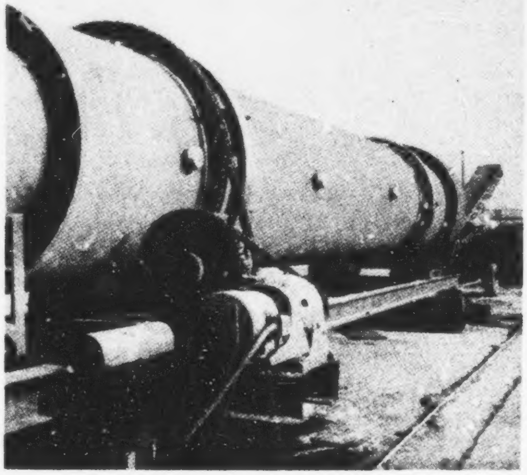


FIGURE 3. The composter is a horizontally-mounted drum, 5 feet in diameter and 30 feet in length. It was formerly used for drying gravel for use as concrete aggregate. The drum is geared to rotate at 0.67 rpm, giving a peripheral speed of 10.5 feet per minute.

FIGURE 4. After the ground rubbish was composted for about six days in the rotary drum, it was piled up in windrows and turned every third day with a skip loader. Internal temperatures at times reached 160° F in the windrows.

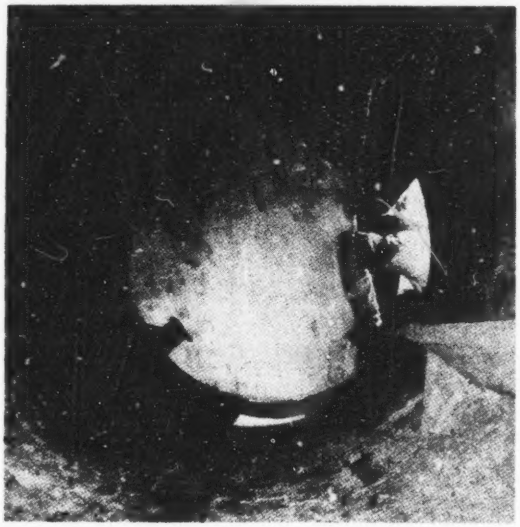


FIGURE 5. To divide the rotary drum into four compartments, steel plates were welded into the drum to provide completely air-tight compartments. Note that the opening through which the welder is working is the position for the transfer box, which will allow the composting material to be discharged from one compartment to the other.

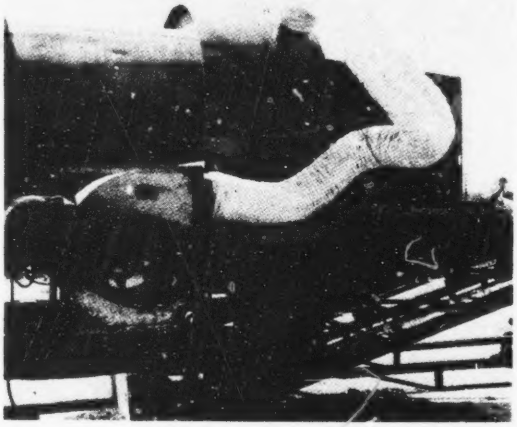


FIGURE 6. A centrifugal blower is located at the discharge end of the rotary drum; the flexible hose connects the blower to the fourth and final compartment of the composter. The centrifugal blower is to be replaced with a positive-displacement blower to permit careful control over the amount of air used during the composting.

of in Los Angeles County, which, if composted, could yield some 5,000 tons daily of compost. It appears quite obvious that the gap between a few hundred tons per day of sewage sludge and a few thousand tons per day of organic compost will not be bridged in a matter of a year or two; in the opinion of the Districts' staff, the development of the market for compost is a prerequisite to successful, large-scale composting of organic refuse for disposal.

In the meantime, the Sanitation Districts are producing compost to be sold through the contractor now processing and selling the digested sewage sludge resulting from the Districts' sewage disposal operations. In this manner it is anticipated that the market for compost will be tested; upon increased demand, additional quantities of compost can be developed to permit the market to expand.

Composting of Refuse. The Sanitation Districts' first experimental operation was quite simple, utilizing an alfalfa shredder for pregrinding of the refuse (figures 1 and 2), approximately six days' detention in a steel rotary drum (a used, concrete-aggregate drier, five feet in diameter and 30 feet in length -- figure 3), followed by several weeks' storage in windrows approximately six feet high and ten feet wide at the base (figure 4). The contractor will screen the completed compost (and perhaps regrind) in order that rags, sticks, and plastic materials may be removed or finely ground prior to bagging. The final preparation of the composted refuse for sale has not yet been accomplished, but it is planned that the contractor will prepare the material for distribution through nurseries for sale to home gardeners.

After producing about 40 tons of compost by the procedure previously described, it was decided to compartmentize the rotary drum to provide for better control. In redesigning the drums, the Sanitation District engineers counseled with Mr. Eric Eweson, Swedish-American biochemist and inventor; Eweson conceived of an ingenious system involving automatic transfer and seeding of refuse as it moves through the compartmented composter, as well as a counter-current forced aeration.

The disadvantages inherent in the uncompartmented drum were as follows:

a. Ground refuse tended to mix fairly uniformly throughout the entire drum rather than to travel slowly from the point of entry to the far end of the drum for later discharge. This would not be a disadvantage if the operation were to be conducted entirely on a batch basis, with the drum being filled at one time and the material retained until the composting cycle had been completed; however, a semi-continuous process is considered more desirable.

b. The uncompartmented drum would not allow for a steady, relatively low rate of feeding, but required that the drum be charged rapidly so as to minimize non-productive time. This necessitated intermittent sorting and grading, requiring much larger equipment than for a uniform, or fairly uniform, rate of feed, or would have required storage for the ground refuse prior to charging the drum.

c. A batch-type operation does not lend itself well to a convenient "seeding" at the various stages of decomposition, while a compartmented drum appears to offer some advantages in providing a residuum of material to commence a prompt and active decomposition in each of several stages.

The rotary drum has only recently been rebuilt to provide for compartments (figure 5); forced ventilation is provided so as to allow careful control over air movement (figure 6). Semi-automatic transfer of compost between the several compartments is provided. There has not been enough time to report upon the performance of the redesigned unit; however, preliminary operations look promising and a full report will be made when data are available.

Sewage Sludge Processing. The disposal of sewage sludge from sewage treatment plants is perhaps the most troublesome problem associated with such disposal works and generally involves the following: First, the removal of sewage sludge from the bottom of settling tanks; second, the transfer of such sewage sludge to air-tight, concrete tanks for anaerobic biological decomposition; third, dewatering of the digested sewage sludge by one of three processes -- chemical coagulation followed by vacuum filtration and mechanical drying, mechanical centrifuging followed by mechanical drying or drying in open windrows, or open-air drying in shallow sludge ponds.

The Sanitation Districts are currently dewatering digested sewage sludge with centrifuges and stock piling the sludge cake in windrows on open fields for air drying. The air drying is an inexpensive process, but sometimes poses odor problems. Mechanical drying in rotary drums, or in other mechanical systems, involves large capital expenditures and heavy continuing costs for fuel. The Sanitation Districts are anxious to investigate the possible use of composting as a relatively inexpensive and odor-free means of decomposing and drying sewage sludge to a marketable moisture level.

The anaerobic sludge digestion process used at most sewage treatment plants is endothermic, requiring the addition of heat energy to raise the temperature of the sewage sludge (a mixture of from 2 per cent to 6 per cent solids in water)to a favorable temperature for mesophilic bacterial activity (85° to 100° F.). One beneficial by-product of this digestion process is the generation of "sludge gas", comprising about one-third carbon dioxide and two-thirds methane; the gas is often used as a fuel for heating the sludge and for driving prime movers.

Composting, on the other hand, is exothermic and the thermophilic bacterial action provides excellent drying temperatures of from 120° up to 165° F. It is proposed that a centrifuged sludge, either digested or undigested and having a moisture content of from 65% to 70%, be mixed with a sufficient quantity of combustible rubbish such that the resulting mixture will have a moisture content of from 50% to 65%. One significant benefit to be derived from the composting of sewage sludge, particularly in mechanical composting units where the environment can be carefully controlled, will be a thorough disinfection of the wastes through exposure to pasteurizing temperatures for periods far in excess of those necessary for minimum protection.

Grinding Rubbish to the Sewer. Another interest held by the Districts in the use of composting for waste disposal involves a strong conviction in the feasibility of using large trunk sewers for conveying ground combustible rubbish to sewage treatment plants. History has recorded the evolution during the early 19th century of sanitary sewers for conveying toilet wastes; within our lifetime there has occurred the addition of ground garbage from food waste disposers installed in several million kitchen and restaurant sinks throughout the country. It seems likely then that the future portends the disposal of paper, cardboard and wood fiber (as well as the entire spectrum of organic refuse commonly termed combustible rubbish) through centrally-located grinding stations which discharge to large capacity trunk sewers for conveyance to sewage treatment plants.

Sewage treatment plants are designed to remove materials which either float or sink when confined to quiescent settling basins and it is anticipated that only relatively minor design changes will be necessary in order to accommodate the greater quantities of water-borne organic material that would result from the added disposal of combustible rubbish. It appears feasible that rubbish-sewage sludges from such disposal systems could be dewatered by centrifuging and stabilized through composting, thereby taking advantage of the very low transportation costs in sewers and the short decomposition time required for aerobic composting.

Much work remains to be done in proving the reasonableness of these hypotheses, but sufficient studies have already been conducted to indicate that it is worthwhile investigating the proposal more thoroughly. The Sanitation Districts will install refuse grinding equipment within the next few months at its South Gate Refuse Transfer Station, where ground combustible rubbish will be washed in a grit separator and then discharged to one of the Districts' trunk sewers which passes immediately by the transfer station.

This pilot operation will be full-scale and should provide basic engineering data relating to the costs of grinding and grit separation, as well as reveal inherent difficulties which may develop in the transportation of the ground material via sewers to the sewage treatment plant. Such a venture appears to be a necessary first step in determining the economics of the proposal; the grinding operation can be compared economically with the current procedure at the transfer station, which involves the truck hauling of the refuse to a sanitary landfill some 22 miles distant.

If the sewer transportation system proves less expensive than the truck transportation system, it appears almost certain that the Districts will make a permanent grinding installation for handling most of the organic refuse, with the inorganic wastes and undesirable organic materials continuing to be truck-hauled to a landfill for disposal.

Conclusion. A start has been made toward determining some of the problems and costs associated with the use of composting as an adjunct to sewage treatment and refuse disposal. Once a "breakthrough" has been made in the creation of a market for compost in Southern California, the natural corollary will be the prompt development of equipment and processes for producing compost. The Sanitation Districts of Los Angeles County are commencing modest composting operations in anticipation of the eventual demand.

3. Abstracts from the American Journal "Compost Science" prepared by John S. Wiley, Savannah, Georgia

Vol. 1, No. 3, Autumn 1960:

pp 5-8. Refuse Composting Plant at Norman, Oklahoma. P. H. McGauhey.

After developmental studies in the early 1950's, the Naturizer Company completed a mechanized composting plant in March 1959 to treat all refuse from Norman, Oklahoma, about 35 tons/day. The four major plant phases are: 1) receiving, sorting, and salvage; 2) grinding and mixing; 3) composting; and 4) screening, bagging, and storage. Provision is made to introduce raw or digested sludge, wet garbage, or water after sorting at the first grinder. Two grinders were developed and patented: the "Pulverator" - a slowly rotating steel cylinder with interior hinged bar hammers, and a horizontal swing-hammermill with studded shell.

The composter consists of two narrow units each with three stories provided with moving floors and followed by secondary hammermills. Retention in the six stories is six days. After the final grinding, the compost is screened and either stored or bagged and sold under the name "Naturizer".

Recently, negotiations were completed for two Naturizer system plants, at North Miami, Florida, and in the San Fernando Valley, California, with Lockheed Aircraft Corp. manufacturing the equipment. 3 pictures. 2 diagrams.

Vol. 1, No. 3, Autumn 1960.

pp 9-10. Composting Sewage Sludge with Municipal Refuse. A.G. Davies

Sewage sludge in England is both difficult to dispose of and beneficial to the composting of municipal wastes but little use has been made of it except on the island of Jersey. Adding sludge to refuse will increase its nutrient value after composting. It may also introduce pathogens but these are destroyed by thermal kill in suitable aerobic, thermophilic composting processes. Control should be exercised, however.

Sludge must be partially dewatered to provide proper moisture for composting with refuse and, possibly, to lower transportation costs. One dewatering method is being tried at Leicester, England, in which a vacuum filter is first precoated with a thick layer of wood flour and then operated with digested sludge, the sludge cake and a thin layer of the flour being cut off with a knife for each revolution. Experiments are continuing and results appear economically promising. Use of sludge-refuse mixtures in composting adds little to the cost of refuse composting, while providing good savings in sewage disposal costs.

Vol. 1, No. 3, Autumn 1960.

pp 12-15. Composting Refuse at Sacramento, California. Clarence G. Golueke

Composting of refuse has been shown to be technically feasible and the economic feasibility may be demonstrated by actual plant installations. The compost, a relatively low value product, can help reduce processing costs but the use of expensive, complicated equipment, requiring high power demands and close operational supervision, must be avoided. Inoculums are unnecessary. The plant must treat the refuse promptly and without equipment failures.

The Dano process, with 52 plants treating about 2000 T/day of refuse, has a long history of success in Europe and Asia. A Dano-type plant near Sacramento has operated since 1956, adapting to American conditions caused by differences in character of refuse. The process steps are: 1) conveying, hand and magnetic sorting with salvage, 2) grinding, 3) composting in a biostabilizer, 4) screening, 5) secondary magnetic separation and grinding, 6) air jet separation of inorganics, and 7) maturation in windrows.

Both grinders are of the hammermill type. The biostabilizer is a slowly rotating drum, 10.5 ft. diam. x 76 ft. long, with air and water valves, which retains 90 to 120 T of ground refuse for one day. The unit provides moisture and aeration control, mixing, and particle-size reduction. Temperatures reach 140°F and the pH is increased to about 7.0 in the drum. About 10 days in the biostabilizer would be required to decompose the high-cellulose refuse, but economics indicate a 1-day detention. Maturing of the compost in windrows is therefore required, preferably with 2-3 turnings.

The compost contains: 1.25% N, 0.4% P_2O_5, 0.3% K_2O, many trace elements, and moisture-holding capacity of over 100% of its weight. Costs of processing the refuse are "considerably less than $3.25 per ton, exclusive of salvage". This compares favorably with the costs of incinerators having air pollution control of $3.25-8.00/ton.

Vol. 1, No. 3, Autumn 1960

pp 22-25. Cannery Waste Disposal by Gerber Products. Max R. Dietz and Ray C. Frodey

The Gerber Products Company, Freemont, Michigan, conserves fruit and vegetable cannery wastes by spray irrigation on 140 acres located 3½ miles from the plant. The wastes contain up to 3000 ppm of 5-day BOD and the pH varies from 4.3 to 11.5. The sprinkler system applies one inch of irrigation in 4½ hours and 2-4 inches are applied per week. The soil consists largely of fine sand.

Different crops have been tested on the irrigated fields; the yield of such cover crops as alfalfa was much greater on the irrigated soil. Several types of trees thrived with moderate application rates of irrigation and the Danish willow withstood heavy spray irrigation. Irrigation can be continued in winter by controlled spraying over a small area so that lagooning is unnecessary in cold weather. The operating cost is relatively low in comparison to other methods of disposal. (2 pictures).

Vol. 1, No. 3, Autumn 1960.

pp 35-37. Air Pollution and Incineration. Thomas Powell.

Air pollution has become an urgent problem in metropolitan areas and inefficient incinerators contribute "in no small measure to this problem". The present waste disposal trend is toward burning because of the disadvantages of other methods. Smoke, dust, and gases may be discharged by incinerators. Contamination of air in U.S. cities is estimated to cost $1.5-4 billion/yr. Air pollution also causes damage to health and sometimes death. Since 1950, more than 20 states have adopted or strengthened air pollution legislation. Some cities, notably Detroit and Los Angeles, include incinerator-caused pollution in their codes. The Air Pollution Control Association is establishing "minimum requirements for the design and operation of all major types of incinerators".

"Appreciation of two facts - that valuable organic matter should be conserved and returned to the soil, and that incineration can cause danger to health - can be expected to make composting assume importance in any future consideration of waste disposal methods by those most vitally concerned." 1 picture. 16 references.

Vol. 1, No. 4, Winter 1961.

p 2. Industry, Organic Wastes and Agriculture (Editorial). S. J. Toth.

Physical deterioration of U.S. soils should be remedied by application of organic wastes beyond the amount available on present-day farms. A wide range of organic wastes from various industries can provide soil improvement and the determination of N, P_2O_5 and K_2O is insufficient in assessing the value of such wastes. It is up to industry to evaluate the agricultural potentials of these residues and not all types will improve the physical properties of soil. In the absence of a centralized industry-supported laboratory, the author suggests use of Research Institutes and Agricultural Experiment Stations. He deplores "that tremendous tonnages of organic industrial wastes, are burned or destroyed and never do get back into the soil from which it originated".

Vol. 1, No. 4, Winter 1961.

p 4. Process Composts Cardboard and Other City Refuse (Technical brief). Charles H. Coleman

Israeli patent 13,033 covers a process of grinding and windrow composting of refuse with forced aeration and with provision for pH control and the addition of fertilizing materials. Grinding reduces particle size to less than 4 cm. in diameter. Windrows, less than two m. high, are placed over pipes with air discharge holes less than 2 mm diameter connected to a blower from which air is supplied at 0.1 in. pressure. Acids or alkalis can be added to control pH and phosphates or nitrogenous materials can be added to improve the fertilizer value of the compost. Composting time is 3-4 weeks.

Vol. 1, No, 4, Winter 1961.

pp 9-10. Proper Grinding -- Key to Efficient Composting. John R. Snell.

Grinding is essential to efficient composting, conserving both space and time. It provides exposure of surfaces to decomposing organisms, mixing and aeration. Proper particle size in important; wet materials should receive a coarser grind than dry materials; and materials to be composted in a mechanical digester may be ground finer than that which would be windrowed.

The author prefers swing hammermills with a large throat and rugged construction. He advocates double grinding or two-stage grinders. Wear is rapid and special alloy steels are advocated along with the rebuilding of hammers with special welding rods. The author believes that experience gained by grinder manufacturers will result in improved design especially for handling U.S. refuse.

Vol. 1, No. 4, Winter 1961.

pp 11-14. Composting City Refuse in the Netherlands. B. Teensma.

This article, by a representative of V.A.M., describes the need for and the growth of municipal refuse composting in the Netherlands, starting with the large van Maanen plant at Wijster in 1929. Compost was needed to rebuild the physical fertility of the soil after 30 years of use essentially of chemical fertilizers. At the end of 1960 there were 15 compost plants (2 van Maanen plants, 8 rasping plants, 4 Dano plants, and 1 hammermill plant) treating nearly 30% of all city refuse in the Netherlands. These systems are briefly described together with the support of the Dutch Government which enabled their development and installation. The author predicts the construction of more compost plants because of the demand for additional compost. The large Wijster plant will be modernized next year.

Vol. 1, No. 4, Winter 1961.

p 23. Construction on Phoenix Compost Plant to Begin February, 1961 (News item).

Final phases of design are in process by the Arizona Bio-Chemical Co. for the 300 ton/day Dano plant to be built in Phoenix. Extra time was taken to inspect European compost plants in order to improve the design. Construction will start in February and it is estimated that the plant will be completed in late summer or early fall. The company will operate the plant and sell the compost to a fertilizer firm which in turn will market it on a retail basis. Reference is made to growing tests by the University of Arizona Agricultural Experiment Station which demonstrated the value of such compost for increasing plant yields.

/Ed. note: The start of construction was delayed until July 1961./

Vol. 1, No. 4, Winter 1961.

pp 26-30. Wood Wastes in Composts. Stuart Dunn and Judith D. Emery.

Four methods of outdoor composting of sawdust, in bins, piles and pits, were tested. The best consisted of composting mixtures in 1 cu. yd. wooden bins, keeping them wet. The second best was in pits with no water added but with occasional flooding at certain times of the year.

Various manures and other materials were tested as aids to composting sawdust in mixtures. Composting was generally for 1-2 years. The compost was analyzed and commercial fertilizer added to make up deficiencies. Tests were done bt growing various types of plants in succession in the compost or compost-soil mixtures in wooden boxes or in greenhouse pots. Yields were determined and compared to each other and to a control (soil only) for each crop and for the accumulation of all crops.

The wooden box cultures revealed best yields from sawdust composts in which hen manure was the composting aid. Next best was a silage-sawdust mixture. Most types giving poorer results than the control were sewage-sawdust combinations.

Both hen manure and chopped green vegetation, mixed with sawdust, produced composts giving good yield increases in pot tests.

Vol. 1, No. 4, Winter 1961.

pp 44-45. Waste Treatment at Hawaii's Oahu Prison. Archie Eriksson.

A composting project has been in operation for eight years at Oahu Prison, composting agricultural and processing wastes from the prison and from many companies on Oahu. The materials are ground in hammermills and composted in windrows 10 to 12 feed wide by 5½ to 6 feet high. A heavy duty hammermill with an elevator is used to turn the piles weekly. Compost time is 3 to 6 weeks, depending on the materials.

Compost is sold in four grades: a fine lawn dressing, a coarse tree-planting compost, a garden potting compost, and a loosely shredded mixture for use as mulch. It is packaged in 1- and 2- cu. ft., 4-ply, paper bags.

4. 2nd International Congress of IRGR.

Preliminary Notice

SECOND INTERNATIONAL CONGRESS
of the
International Research Group on Refuse Disposal (IRGR)

on
DISPOSAL AND UTILIZATION OF
SOLID DOMESTIC AND INDUSTRIAL WASTES

at
"Haus der Technik", Essen, Germany, May 22-26, 1962

In connection with preparations for the 10th anniversary of "Arbeitsgemeinschaft für kommunale Abfallwirtschaft (AkA)",Baden-Baden

Organization: Haus der Technik e.V., Essen, in cooperation with the IRGR, Zürich, and the Arbeitskreis Müll und Stadtkehricht des Ruhrgebietes, Essen.

Scientific Direction: Dr. O. Jaag, Zürich; Engr. C. Kachulle, Essen; Dr. H. Straub, Baden-Baden.

Lectures and discussions will be held on the following subjects:

1) Present-day refuse disposal requirements and problems.
2) Landfilling of solid wastes.
3) Analysis of solid wastes (domestic refuse, industrial wastes, sewage sludge) with regard to possibilities of their utilization.
4) Physical, chemical and biological processes for composting solid wastes.
5) Processing technics for composting solid wastes including dewatering of sewage sludge.
6) Results of the use of compost.
7) Possible uses of compost in special cases.
8) Processing technics for incineration.
9) Possibilities for utilization of the energy and the residue from incinerators.
10) Factors in planning an installation for disposal and utilization of solid wastes.

Those interested in this congress are requested to send their names and addresses to Haus der Technik e.V., Schliessfach 668, Essen, Germany, which will provide additional information.

5. Technical Publications Received by the Secretariat.

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